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Learning From Electronic Texts: Effects of Interactive Overviews for Information Access

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This research investigated the effects of structured and unstructured overviews on learning from electronic text. It compared review strategies and text representations developed for traditional continuous text and for electronic text with a structured overview (a hierarchically organized map of the text content) and an unstructured overview (a menu-like content listing). Both overviews produced better memory for text topics and better breadth of recall compared with traditional text. However, when readers lacked specific study goals, the unstructured overview produced a more fragmented knowledge structure. This suggests that minimally structured overviews may be better for specific learning tasks than for gaining familiarity with new topics. The structured overview was easier for readers to recall and use. It also increased the amount of review when readers lacked specific study goals, suggesting that the overview design influences the extent to which readers take advantage of the flexibility provided by electronic text overviews.

Electronic texts are increasingly common in schools and homes. These texts include reference materials such as dictionaries and encyclopedias, as well as novels and instructional programs. A major advantage of electronic texts is that they can provide direct information access through facilities for locating and displaying specific text content (Duchastel, 1990; Jonassen, 1988; Tsai, 1988; Weyer, 1982). Access facilities for electronic text vary, depending on the nature of the text and the flexibility desired in allowing readers access to all or part of the information available. Common approaches include providing indices, overviews of the text content, various search capabilities (such as word searches), and "hot" text (consisting of words in the text that can be selected to view additional related content). This research investigated the effects of one type of

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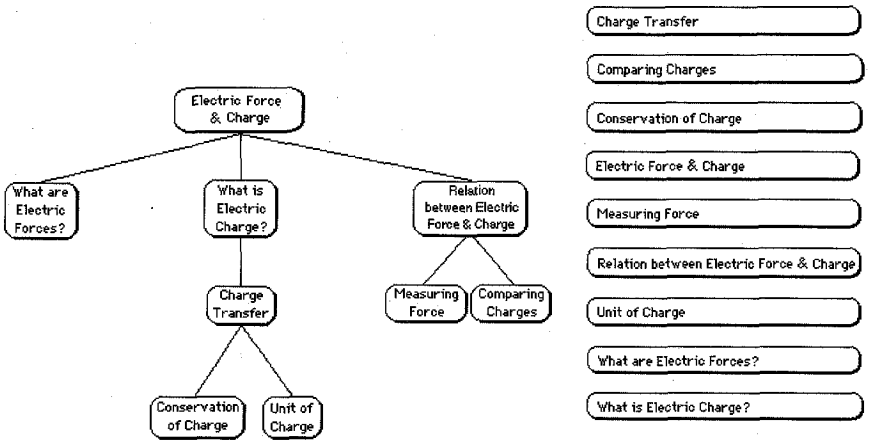
electronic text access facility, content overviews, on readers' study strategies and memory for instructional text.

Complex electronic instructional systems, such as large hypertexts, typically provide readers with more than one type of access facility. However, almost all instructional electronic texts include at minimum an overview indicating the available text content (Jonassen, 1986). This type of overview is considered to be important in helping readers develop effective study strategies, particularly for texts allowing relatively free access to information (Halasz & Conklin, 1989; Heller, 1990; Jonassen, 1986; Tsai, 1988). Content overviews typically provide descriptors (i.e., headings or labels) representing content areas or topics available for study. Readers display text segments by selecting the corresponding label from the overview. The overview can specify the entire text content or the topics at one particular level of a text hierarchy (Billingsley, 1982; Weyer, 1982). Importantly, the overview may also either provide organizational information about how the text units relate to each other or leave the units unstructured so that readers can impose their own content organization.

This research investigated the effects of structured and unstructured electronic text overviews on study strategies and text representations. Text review and recall were compared for an electronic text studied with a structured and an unstructured overview and for a traditional continuous text also presented on a computer. The electronic text was similar in design to a simple *chunked* or *node-link* hypertext (Jonassen, 1986). The text content was divided into information units that served as the nodes in the electronic text. Each unit had a title indicating its content, and these titles appeared on an overview that provided access to the units. Readers clicked on the overview titles with a mouse to display the contents of a unit on the screen. In the structured overview, the spatial layout of the titles indicated the superordinate and subordinate relations among the text units (see Figure 1a). The unstructured overview presented the titles as an alphabetized list (see Figure 1b). The traditional text consisted of the same units presented as sequential screenfuls of text through which readers could move forward or backward (see Figure 1c). The unit titles served as headings and subheadings in the traditional text.

Our research examined how these types of interactive overviews influence text review strategies, as well as the nature of the resulting text representations. Specifically, it addressed the following questions:

1. Does the interrupted nature of text study with an interactive overview (i.e., the need to alternate between the overview and the learning material) hinder the development of a coherent text representation, and does a structured overview overcome this potential difficulty?
2. Does the central role of the overview in studying electronic text cause it to become part of the reader's text representation, and does memory for the overview then function as a recall cue for the text content?



(a) Structured overview. (b) Unstructured overview.

Electric Force and Charge

The electric force is a fundamental force of great importance. Because it is responsible for the interaction between atoms and molecules, it accounts ultimately for most phenomena studied in physics, and for all phenomena studied in chemistry and biology. Furthermore, it leads to an enormous range of practical applications in all technology and instrumentation. This text discusses the basic properties and implications of electric forces and electric charge.

I. What are Electric Forces?

The ancient Greeks as long ago as 600 B.C. knew that amber rubbed with wool acquires the property of attracting light objects, such as pieces of paper. This same phenomena can be demonstrated by running a rubber comb through dry hair, or against a carpet or a cat's fur--light objects will be attracted to the comb. In describing this property today, we say that the rubbed amber (or comb) exerts an electric force on other objects. If the object is light enough, we see it move in response to this force.

What is the nature of this electric force? It is not a force that requires physical contact between two objects. The paper scrap rises towards the comb without the comb touching it. It is not the force of gravity. Gravitational forces are very small unless one of the objects has an extremely large mass. The earth exerts a gravitational force on a scrap of paper, making it fall to the floor when dropped, but a comb is not massive enough to attract the paper through a gravitational force.

An interaction like that between the comb and paper (which is not an interaction through contact or a gravitational interaction), is called an electric interaction. It is due to an electric force created

Next Page

(c) First page of traditional text.

FIGURE 1 (a) Structured overview for the hierarchical electronic text, (b) unstructured overview for the list electronic text, and (c) first page of the traditional text (also presented by computer).

3. Does the easy information access provided by the overview increase the amount of study relative to that for traditional text, and does this increase vary with the overview format?
4. Are differences in study strategies and internal representations formed with the three text formats reduced when readers have a well-defined learning goal to guide text processing?

INTERACTIVE OVERVIEWS AND TEXT PROCESSING

An interactive overview allows readers to locate easily information from a large, electronic-text database. In the case of reference texts, this is an obvious advantage, because the purpose of such texts is to provide ready access to specific information. For instructional texts, however, the implications of providing an overview are less clear. Readers of instructional text are less interested in locating specific information than in selecting and interrelating information to achieve a learning goal. In this case, readers go beyond simple information location and develop a coherent representation of some or all of the text content.

Traditional text presents a continuous linear flow of information, and readers build an internal representation of the content by taking the high-level ideas and relating lower level content to these ideas (W. Kintsch, 1986, 1988; van Dijk & W. Kintsch, 1983). The building of the text representation around main ideas is largely based on the repetition of text topics, with readers linking new information to previous information about a topic. When the topic changes, readers must search memory to determine if the new topic is related to earlier knowledge and, if so, must reinstate that portion of the text representation in memory. If the topic is unrelated, the reader must incorporate the new topic into the representation being constructed. Both of these processes are time-consuming and effortful (Kieras, 1981; Lorch, Lorch, & Matthews, 1985; van Dijk & W. Kintsch, 1983). In addition to building a detailed representation of the content at the local level (the microstructure), readers develop a more general representation of the global meaning of the text. This latter representation, the *macrostructure*, is a representation of the main points or gist of the text formed by selecting or generating superordinate generalizations encompassing text details (van Dijk & W. Kintsch, 1983).

The ability to develop good global and local text representations depends on how easily readers can interrelate the content and how thoroughly they process text details. Well-written traditional text facilitates the development of an integrated text representation through careful sequencing of related ideas, early presentation of thematic statements tying together text details, and the use of familiar text organizations in structuring text information (Charney, 1994). These text features help readers interrelate the text content and develop a coherent and stable internal representation. Compared with traditional text, electronic text with an overview changes the nature of the representation-building processes in several significant ways:

1. Text processing is interrupted by unit selection as readers choose units from the overview.
2. The unit labels and their arrangement on the overview become an important additional component of text study, because these labels are used to select information.
3. Organizational information is either external to the text proper (in the overview) or eliminated (with unstructured overviews).

4. Text review and exploration are easier, because the interactive overview provides immediate access to desired information.

These differences in text processing between traditional text and electronic text with interactive overviews would be expected to influence both text study strategies and the resulting internal representation for the content. We consider each major difference in turn.

Interruption of Text Processing

With traditional text, readers move from unit to unit, so that text processing is continuous. An interactive overview interrupts text processing because readers move back and forth between the text units and the overview used for selecting units. This discontinuity in text study could have two effects on the representation formed for the content.

First, interruptions in text study could interfere with the development of an integrated representation of the text as a whole. Building a unified representation of the learning material would be more effortful, because readers would have to reinstate the information from prior text units each time they selected a new unit in order to link this unit to previous content (Graesser, Hoffman, & Clark, 1980; van Dijk & W. Kintsch, 1983). This effect would cause difficulty in identifying the main ideas in the overall text.

Second, interrupted text study may increase the depth of processing of content within each unit by focusing attention on the individual unit. Because readers expend effort in selecting a unit (rather than following a continuous flow of text), they may focus more attention on the unit when it is displayed. They may also process the units they read to a similar degree (independent of the importance of their content). This effect would produce a more extensive and deeper representation of the text details within units and better recall for this content. It would also result in greater breadth of recall for the text relative to traditional text, because traditional text readers would be more selective in the attention given to different text segments (Anderson, 1982; Dee-Lucas & Larkin, 1988).

Requirement to Attend to Unit Labels and Structure

Interactive overviews present the text content as discrete labeled units. The manner in which the text is segmented into units and the unit titles are highly salient to the reader, because this information guides text search and study. Although traditional text usually contains titles in the form of headings and subheadings, these are less prominent, because they are processed as an integral part of the text and are not used for information selection (see Brooks, Dansereau, Spurlin, & Holley, 1983; Lorch, 1989).

Because of their prominent role in text study, the overview titles and their organization may be incorporated into the text representation as superordinate topics subsuming the information within units. This could have two effects on

text recall. First, the unit titles (and their structure on the overview) would likely be better recalled than corresponding headings and subheadings from traditional text (Egan, Remde, Landauer, Lochbaum, & Gomez, 1989). Second, these titles could be effective as recall prompts and thus increase recall for the text content. By recalling the titles, readers may be able to recall the content of the associated unit, resulting in better memory for text details (Meyer, Brandt, & Bluth, 1980). This would also result in greater breadth of recall by increasing the number of units from which content could be recalled (Lorch & Lorch, 1985).

Lack of Organizational Cues Within the Text Units

Traditional text includes familiar rhetorical indicators of importance and organization within the text content. In contrast, an interactive overview provides organizational information external to the units of the text proper. An overview can provide a more or less complete structure for the text units through the spatial layout and linking of the unit titles. Although this separation of organization and text focuses attention on the overview titles and format (as mentioned earlier), it also requires readers to integrate these two sources of information.

If the overview provides a complete structure for the units, readers must incorporate the unit content within the overview structure to determine how the content is related to the text as a whole. Although this requires additional processing, prior research with traditional texts and structural overviews (providing prior information regarding the organization of the text) suggests that readers are not likely to find this type of integration difficult for overviews having uncomplicated structures (see, e.g., Mannes & W. Kintsch, 1987; Mayer, 1979). If the overview provides a partial structure or is unstructured, however, the reader must both determine how the unit topics are related and integrate the unit content within that organizational framework. The potential difficulty of generating an organization for the text units may result in a poorly integrated representation (Jonassen, 1986). This is suggested by research with unstructured or poorly structured traditional texts, indicating that recall for these texts is often poorer than for well-structured texts (W. Kintsch, Mandel, & Kozminsky, 1977; W. Kintsch & Yarbrough, 1982; Schwarz & Flammer, 1981). Without an organizational framework, readers provided with an unstructured overview may process the text units as independent text segments rather than expend the effort required to determine how they are related. This would result in their having greater difficulty in identifying the main points from the text as a whole, compared with readers given traditional text or a structured overview.

Ease of Information Access

Interactive overviews allow readers to access directly a desired portion of the text without linear search through the text as a whole. This direct information access facilitates both review of difficult or interesting material and exploration of

unrelated or tangential content. Because the costs associated with accessing information are relatively low, interactive text overviews may increase text exploration and review relative to traditional text. The extent of this effect, however, may depend on the nature of the overview (Wright, 1991). The structured overview may particularly facilitate text review because the organization of the units provides guidance about units that might usefully be reread (e.g., by indicating clusters of units relating to a particular topic). Additionally, initial text study with a structured overview may result in a better integrated internal representation of the text, which could then aid in guiding subsequent text review. These effects would produce more optional review with a structured overview than with an unstructured one.

OVERVIEW OF EXPERIMENTS

To compare directly representations developed with the two electronic texts and the traditional text, all readers first read all units once in the same specified order and then reviewed any material they chose. This was done to ensure that the initial learning content was constant for all readers (i.e., they all read the same material in the same sequence) and, thus, to focus on the effects of the different access facilities on text review and learning for the same material.

Two experiments examined the effects of interactive overviews on text review strategies and on the content and cohesiveness of the resulting text representation. In the first experiment, readers had a general learning goal of preparing for an unspecified test. Because this learning goal does not provide guidance for processing the text, it was anticipated that readers would rely on features of the text format and content in developing their study strategies. In this case, readers would use the unit content and the overview (or the traditional text headings) to determine what information was most likely to be important for the learning goal. It was anticipated that readers using the unstructured overview would simply process the units as individual segments of information, so the result would be a poorly integrated text representation compared with that developed from traditional text. This would be consistent with research with traditional text indicating that, without a strong learning goal, readers tend to adopt the organization used by the author and to develop a text representation matching that of the text (Meyer et al., 1980). With the structured overview, however, readers could use the organizational information in the overview to develop a coherent representation similar to that of traditional text, even without a specific learning goal.

The results of the first experiment suggested that readers with the unstructured overview had difficulty developing a good representation of the text as a whole. Based on this finding, a second experiment was conducted in which readers were given the goal of preparing to write a summary of the text. This task requires readers to develop a coherent global text representation and, thus, it assessed their ability to overcome difficulties in integrating information with the unstructured overview. It was anticipated that, with this specific goal requiring topic

integration, readers would be able to generate strategies for developing more integrated representations (E. Kintsch, 1990; Lorch et al., 1985). Constructing this global representation, however, would require additional effort for readers with the unstructured overview. Therefore, it was expected that text review would be greater with the unstructured overview than with the other two texts, reflecting the need to generate and assess an organization for the text units.

In both experiments, readers' text representations were examined through reader summaries of the main points of the texts and free recalls of the text content. The integration of unit titles in text representations was examined in two ways. To assess whether unit titles were incorporated into the text representations, readers recalled these titles using a paper copy of the overview with blank spaces instead of the titles. (Readers of traditional text used a blank outline of the headings and subheadings.) They recalled the titles (or headings) and indicated their locations on the overview or outline. To assess the utility of titles or headings as cues to text content, the complete set of unit titles or headings was then used as a recall prompt. Readers' unit selections and study times were automatically recorded by the text display program. These were used to characterize reader study strategies.

EXPERIMENT 1

This experiment examined the effects of structured and unstructured overviews on text study and the resulting representation when readers had a general learning goal. It was anticipated that text integration would generally be more difficult with the interactive text overviews than with traditional text but would be facilitated by the structured overview providing organization for the units. The overviews were expected to result in better recall of the information within the units and for the unit titles themselves compared with the traditional text. Furthermore, the unit titles were expected to be better recall cues for readers with the overviews. In the absence of a specific learning goal, text review was expected to depend on ease of use of the interactive text overviews, as well as on the quality of the global text representations, resulting in more review with the structured overview.

Method

Materials

The text discussed electric force and charge and was 1,970 words in length. All three text formats were identical in content. Each contained 9 units, ranging in length from 72 to 299 words. Each electronic text unit (and traditional text page) was seen as a single computer screen display. Readers moved between screen displays by clicking on buttons with a computer mouse.

The traditional text was formatted in the standard way with headings and subheadings that corresponded to the unit titles in the electronic text. The text

was segmented so that each page of text filled one screen. Thus, one unit might be split between two pages, and one page might contain more than one unit, as would be the case with traditional continuous text. There were 7 screens of text, with the length of full screens ranging from 266 to 328 words. The length of the last screen (a partial screen of text) was 192 words.

The unit titles on the interactive text overviews were the same as the headings and subheadings in the traditional text. The structured overview presented the unit titles in a hierarchy indicating the subordinate and superordinate relations among them. This condition is referred to as the *hierarchical* electronic text. The unstructured overview presented the unit titles as an alphabetized list. This condition is referred to as the *list* electronic text. The two electronic text overviews and the first page of the traditional text are presented in Figure 1.

Participants

The readers were 45 undergraduates (three groups of 15 each) who had completed not more than one semester of college-level physics. This restriction on physics instruction was chosen to ensure that the readers had had limited exposure to physics. The content of the text was elementary enough to have been covered at a simple level in basic high school physics, so that terms and basic concepts could be understood without explanation in the text. The limitation on college-level physics was designed to ensure that the readers had not developed expertise in the area, so that they would need to process the text thoroughly to complete the assigned study goals.

Procedure

The experimental materials were displayed on a Macintosh SE/30 using Hypercard. The instructions stated that readers were to study the text in preparation for a test on its contents. They were told to study the text first in the order specified and then to review any portion of the text in any order. With the traditional text format, readers went through the text linearly, one screenful after the next, by clicking on a *Next Page* button. After the last page, two new buttons were automatically added to the screen, labeled *Previous Page* and *Finished*, and readers saw instructions indicating that they could use these buttons to move forward and backward in reviewing the text. With the electronic texts, readers first saw the overview of the unit titles. Each title was a button for displaying the corresponding unit. During the initial reading, a message at the bottom of the screen indicated what unit to select. Readers clicked on the button for the indicated unit, which was then displayed for study. When they had finished studying the unit, they clicked on a button that took them back to the overview, where a new message indicated the next unit to select. When they completed study of the last unit, they returned to the overview and saw a message indicating that they could select any of the units for review.

Prior to studying one of the experimental texts, all readers used a practice text familiarizing them with the study procedure. The practice electronic texts had an overview that matched in form that of the corresponding experimental text, and readers selected the practice units specified at the bottom of the screen in the same manner as the experimental texts. The instructions were identical for the two overview groups, except that the overview was referred to as either a *content map* (hierarchical overview) or a *content list* (list overview). The practice traditional text had continuous screenfuls of text, with buttons for moving through the text. All practice texts also allowed readers to review in the same manner as the experimental texts. The content of the practice text consisted of instructions about the study procedures for the corresponding experimental text.

After studying and reviewing the experimental text, readers completed (a) a written summary of the main points of the text, (b) a written free-recall of the text, (c) a recall test for the unit names (for the overviews) or for the text headings and subheadings (for the traditional text), (d) a cued recall with the unit names (for the overviews) or the text headings and subheadings (for the traditional text) as the cues, and (e) an open-ended evaluation of the usability of the experimental text. For the summary, readers were instructed to write up to 25 sentences including the main points of the text. This length limitation was intended to encourage readers to select from and condense the text material to its main points. The free recall required readers to write down everything they could recall from the text. The test for recall of unit names and locations used a paper copy of the overview with the unit titles omitted. The outline included the numbers and letters for the headings and subheadings (i.e., A, B, I, II, etc.), with appropriate spatial indentation in the outline. Readers were asked to recall the content of the unit titles and, if possible, to indicate their location on the overview or outline. For the cued recall, learners were given the overview or text outline with the titles included and were instructed to write down any additional information that they had not included in their earlier free recalls. The evaluation of the usability of the experimental texts asked readers to indicate whether the text was easier or more difficult to use than traditional printed text and to justify their response.

Initial reading and review times for each electronic text unit and each screenful of traditional text were recorded by the text display program. For the electronic text, reading times were recorded as the times between mouse clicks on the buttons for accessing the unit (from the overview) and for leaving the unit to return to the overview. For the traditional text, reading times were recorded as the time between mouse clicks on the buttons that allowed the readers to move sequentially through the screenfuls of text.

Results

The results are presented in four sections. The first examines readers' study and review processes, including time to use the overviews and frequency and content of text review. The second section presents differences in readers' global text

representations as indicated by their ability to summarize the texts. The third section examines text representations at the local level, including unit title recall. The final section presents readers' evaluations of the experimental texts. For measures analyzed with an analysis of variance (ANOVA), all comparisons of the means were done with the Newman–Keuls test with $p < .05$.

Study and Review Processes

Time required to use overviews. The time readers spent on the interactive text overviews during initial study and review was analyzed to determine whether readers found one overview easier to use. An ANOVA on the mean time spent on the overviews during initial study showed that readers spent longer on the list ($M = 5.49$ sec) than on the hierarchical ($M = 4.18$ sec) overview, $F(1, 28) = 5.36$, $MSE = 2.38$, $p < .028$. Thus, it was easier to locate the unit titles on the hierarchical overview.

The time spent on the overviews during review was analyzed to determine if the hierarchical overview was also easier to use when readers were familiar with the organization and location of unit titles and could select units freely. An ANOVA again indicated that readers spent more time on the list overview, $F(1, 16) = 8.04$, $MSE = 7.43$, $p < .012$, showing that the hierarchical overview was easier to use in deciding what to review, as well as for initial reading. The mean review times were 3.7 sec for the hierarchical overview and 7.8 sec for the list overview.

Text study and review. Initial reading times were examined for differences in time spent on the first reading of the text. For text review, comparisons were made in the proportion of readers choosing to review, the proportion of units reviewed, the amount of time spent reviewing, and readers' tendency to review important versus less important units.

1. *Initial time on text.* An ANOVA on the initial reading time for each text format indicated no significant differences. Thus, even though readers located the units more quickly with the hierarchical overview, there was no difference in the time spent studying the content once the unit was reached. This suggests that initial study was guided by local characteristics of the text (e.g., length, word frequency, syntactic complexity) rather than by the manner in which the material was formatted and accessed. The mean initial reading times were 8.85 min for the traditional text, 9.89 min for the list electronic text, and 10.87 min for the hierarchical electronic text.

2. *Proportion of readers reviewing.* One indication of the extent to which readers were predisposed to review the different text formats is the proportion of readers opting to review any part of the material. The proportions of readers reviewing were .93 for the traditional text, .87 for the hierarchical electronic text, and .47 for the list electronic text. A z test on the differences among these proportions indicated that significantly fewer readers chose to review with the

list electronic text than with either the hierarchical electronic text or the traditional text, with no difference between the latter two.

3. *Proportion of units reviewed.* The average proportion of units reviewed by readers reviewing at least one unit was calculated for all three text formats. In the case of the traditional text, this calculation was made for the proportion of text screens reviewed. The 13 readers reviewing with the hierarchical electronic text reviewed an average of .50 of the units, whereas the 7 readers reviewing with the list electronic text reviewed an average of .30 of the units. The 14 readers who reviewed with the traditional text reviewed an average of .95 of the screens. With this text, however, readers had to page through sequential screenfuls of text to find the information that they wanted to review, so the proportion of screens reviewed includes both intermediate screens that readers passed over and screens that they reread for additional study. Because these two processes could not be separated with the traditional text format, only the review data for the two electronic texts were analyzed. This analysis on the proportion of units reviewed by each reader (for those readers reviewing at least one unit) indicated no significant difference in the amount reviewed for the two text formats. Although the absolute difference between these proportions is large, it is not statistically reliable, possibly because relatively few readers reviewed the list electronic text.

4. *Time spent reviewing text.* The average total review times for readers who chose to review were 53 sec for the hierarchical electronic text, 75 sec for the list electronic text, and 109 sec for the traditional text. Although a significantly longer time was spent reviewing the traditional text than the hierarchical electronic text, $F(2, 33) = 5.76$, $MSE = 1{,}888.50$, $p < .008$, review time for the traditional text included time spent seeking information (by paging and skimming sequentially through the text), so total review time for the traditional text would be expected to be relatively high. There was no significant difference in total review times for the two electronic text formats.

Unlike the initial reading of the text, review was completely under the readers' control and therefore readers differed in which units they opted to reread. Because the individual units varied on characteristics such as length and syntactic complexity, the amount of time spent reviewing was determined by the specific units selected, as well as the text format. Therefore, a multiple regression analysis was run on the logarithm of the time spent by each reader reviewing each unit (for those units reviewed). The data for the traditional text were not included in the analysis, because, as noted earlier, search times and review times cannot be separated for this text. The independent variables included in the regression were unit (the unit reviewed) and text format (list or hierarchical electronic text). Reader was also entered as a categorical variable to account for individual differences in study time. The coefficients for the regression model (without the reader coefficients) are shown in Table 1. Because unit was entered as a categorical variable, a separate coefficient was obtained for each of the 9 units, as shown in Table 1.

TABLE 1
Parameter Estimates and Standard Errors for a Regression Model of the Log of the Review Times (in Seconds) From Experiment 1

Variable	*Coefficient*	*SE*	*p*
Intercept	1.189	—	—
Text format	−0.250	0.052	.01
Unit			
1	0.126	0.115	.28
2	0.071	0.112	.53
3	0.055	0.104	.60
4	−0.031	0.111	.78
5	0.057	0.088	.52
6	0.151	0.085	.08
7	−0.317	0.097	.01
8	0.089	0.106	.41
9	−0.200	0.143	.17

Note. $R^2 = .67$; multiple $R = .82$.

The coefficient for text format indicates that the amount of time readers spent reviewing differed reliably between the hierarchical and list electronic texts. That this coefficient was negative shows that readers of the list electronic text spent more time on the units reviewed than did readers of the hierarchical electronic text. The estimated unit review times based on the coefficients from the regression model were 8.70 sec for the hierarchical electronic text and 27.45 sec for the list electronic text. Thus, readers who reviewed the list electronic text spent a relatively long time on the units they reread, suggesting that they were less likely to skim information casually during review. The coefficients for units in Table 1 indicate that some units were reviewed longer than others. This is to be expected, given that units differed in length and syntactic complexity.

5. *Content reviewed.* To determine whether readers preferentially reviewed units containing the most important ideas, the number of readers reviewing each unit was correlated with the number of important ideas in the unit. The important ideas were identified in a separate experiment in which readers selected the most important ideas from the traditional text version of the learning material. The text was presented on paper as traditional text to compare the ideas considered to be important when studying the material in electronic text form with those considered important when the material was studied as standard text. The readers were undergraduates who matched in physics expertise the readers in the main study. Readers read through the text completely and then selected the 15 most important sentences. *Most important* sentences were defined as those that the readers thought were most important to learn if they were going to be tested on the contents of the text in a course. A set of 13 sentences (selected by at least 10 of the 18 readers in the study) was identified as expressing the main ideas of the text as a whole. The number of main ideas included in a single unit ranged from 0 to 3.

A correlation was performed between the number of readers reviewing each unit and the number of main ideas in the unit for each electronic text. This correlation was not done for the traditional text data due to the difficulty of distinguishing text search from text review. For the hierarchical electronic text, there was a marginally significant correlation between number of important ideas in the unit and number of readers reviewing that unit ($r = .660$, with a critical value of .666 at the .05 level), indicating that readers tended to review the units that contained the greatest number of important text ideas. The correlation is only marginally significant, in part because there were few observations for this analysis (9 units). The corresponding correlation for the list electronic text was .302, n.s. Very few readers reviewed with this text, however, so it would be difficult to obtain a significant correlation.

Global Text Representation

To assess differences in global text representations, readers' summaries were scored for the number of main ideas they included. The main ideas consisted of the set of 13 sentences identified in the separate study discussed earlier. To determine whether these ideas were included in readers' summaries, the summaries were scored against a propositional analysis of the text (Bovair & Kieras, 1981). Each text unit was analyzed into a set of propositions, and the summaries were scored for which propositions were present. In scoring the summaries, a main idea was judged as included if all its main propositions (i.e., those that expressed the main point of the sentence) were included. An initial examination of the data indicated that one summary of the traditional text contained no main ideas. The contents of this summary indicated that this reader did not understand the summary instructions to include the main points of the text. Accordingly, the data for this reader were considered to be outliers and were dropped from the analysis. A subset of 15 of the remaining 44 summaries was scored independently by two scorers, and there was 90% agreement on which of the text propositions had been included in the summaries.

The summaries were analyzed for the total amount of information included to determine if one group wrote more extensive summaries than the others. An ANOVA on the total number of text propositions in the summaries indicated no significant differences among the three text formats. Thus, the length of the summaries did not vary significantly in terms of the amount of content included from the text.

An ANOVA on the proportion of text main ideas included in the summaries indicated a significant effect of text format, $F(2, 41) = 3.91$, $MSE = 0.027$, $p < .028$. Summaries for both the hierarchical electronic text and traditional text contained more main ideas than the list electronic text, with no significant difference between the traditional text and hierarchical electronic text. The mean proportions of main ideas included in the summaries were .63 for the traditional text, .67 for the hierarchical electronic text, and .51 for the list electronic text.

This suggests that readers with the list electronic text had more difficulty determining what was important in the text as a whole.

Local Text Representation

Local text representations were examined by assessing readers' ability to recall unit titles, the extent to which the unit titles were effective as recall prompts for the unit content, and the amount and breadth of unit content recalled.

Unit title recall. The degree to which the unit titles were incorporated into readers' text representations was determined by assessing their ability to remember both the unit titles and the title locations on a blank copy of the overview or an outline of the traditional text. As expected, title recall was significantly better with both versions of the electronic text than with the traditional text, $F(2, 42) = 15.08$, $MSE = 0.020$, $p < .001$. The mean proportions of titles recalled were .13 with the traditional text, .39 with the hierarchical electronic text, and .36 with the list electronic text. However, the hierarchical electronic text produced better recall of title locations than either the list electronic text or the traditional text, $F(2, 37) = 6.76$, $MSE = 0.012$, $p < .003$. The mean proportions of recalled titles whose location was accurately recalled were .05 for the traditional text, .21 for the hierarchical electronic text, and .11 for the list electronic text, with no significant difference between the list electronic text and traditional text. Thus, although unit titles were equally well recalled with the two electronic texts, readers were not able to recall title locations on the list overview.

Cued recall. Both the free recalls and the cued recalls were scored against the propositional analysis of the text for the number of text propositions recalled. Two scorers independently scored a subset of 15 of the recalls, and there was 95% agreement on which propositions had been recalled. For the cued recalls, any propositions that were also recalled in either the summaries or free recalls were eliminated from the analysis, and an ANOVA was performed on the total number of additional propositions recalled on the cued recall test. The results indicated no significant differences due to text format. The cued-recall scores were very low for all groups. Readers recalled an average of 4 additional propositions with the hierarchical electronic text, 6 additional propositions with the list electronic text, and 4 additional propositions with the traditional text. Thus, there was no evidence that the titles on the overviews were more effective than the headings in the traditional text for cueing additional passage recall. That the cued recall was very low for all groups suggests, however, that readers recalled as much of the texts as they could remember in doing the summaries and free recall, and, therefore, the overviews could not function as recall prompts.

Free recall. The free recalls were scored for the proportion of propositions recalled correctly and incorrectly from the total of 322 propositions contained in the text. A *correctly recalled proposition* included substitutions accurately rep-

resenting the gist of the text proposition. *Incorrectly recalled propositions* were those that corresponded to text propositions but contained an incorrect substitution for one of the proposition elements. Any recall that did not correspond to propositions in the text was not scored. Some readers had included in their summaries propositions that they omitted from their free recalls. These propositions from the summaries were added to the free-recall data to make this measure a better indicator of ability to recall the text as a whole.

1. *Proportion of units in recall.* An ANOVA was performed on the proportion of text units from which at least one proposition was recalled. The results indicated a significant main effect of text format, with more text units included in recall of the electronic texts than of the traditional text, $F(2, 42) = 4.93$, $MSE = 0.015$, $p < .012$. The mean proportions of units recalled were .77 for the traditional text, .90 for the hierarchical electronic text, and .87 for the list electronic text. Thus, the two electronic texts produced better recall of the range of topics included in the text than did the traditional text.

2. *Proportion of propositions recalled.* To determine how much of the text content within units was recalled, an ANOVA was conducted on the proportion of propositions recalled from the text, including recall errors. The mean proportion of recalled propositions that were scored as errors was very low: .06 for each of the three texts. Thus, errors were not analyzed separately but were included in the analysis of overall recall. The ANOVA on the total proportion of propositions recalled indicated no significance differences due to text format. The mean proportions of text propositions recalled were .23 with the hierarchical electronic text, .19 with the list electronic text, and .20 with the traditional text.

3. *Proportion of propositions recalled per unit.* To determine if the electronic text format produced greater clustering in recall (i.e., given that a unit was recalled, a relatively high proportion of information from that unit could be remembered), the mean proportion of propositions recalled by each reader from each unit recalled was analyzed. Recall from the traditional text was scored in terms of the electronic text units to determine by comparison whether the unit divisions with the electronic text promoted clustering of recall. An ANOVA indicated no significant differences due to text format. The mean proportions of propositions remembered from each unit included in recall were .22 for the list electronic text, .26 for the hierarchical electronic text, and .25 for the traditional text.

Reader Evaluations

To evaluate readers' opinions of the text formats, readers completed a postexperiment questionnaire asking them to indicate whether they found the computerized text to be more difficult or easier to study than traditional printed texts and why. Proportions of readers indicating that the experimental text was easier to use, more difficult to use, or equal in difficulty compared to traditional printed text are shown in Table 2. A multiway frequency analysis was conducted on

TABLE 2
Proportion of Readers in Experiment 1 Judging the Difficulty of Using Each Computer-Presented Text Format Relative to Traditional Printed Text

Computerized Text Format	*More Difficult*	*Easier*	*No Difference or No Opinion*
Hierarchical electronic text	.13	.73	.13
List electronic text	.47	.40	.13
Traditional text	.47	.33	.20

these data, excluding readers who indicated no preference. The results showed that the best fitting model was the saturated model including an interaction between text format and response.

To examine the preference data in more detail, a series of z tests was performed on the proportion of readers shown in Table 2 judging the experimental texts as easier than printed traditional text. This analysis indicated that significantly more readers preferred the hierarchical electronic text than preferred the traditional text (compared with printed text), with no difference between the list electronic text and these two texts. The reasons given by those readers preferring their experimental text over traditional printed text were categorized according to the basis for their response. Readers of the hierarchical electronic text overwhelmingly indicated that they preferred the electronic text due to the ease of determining the *information organization.* Comments included "use of button hierarchy gives a good overview," "relationships were given in ways that were easy to visualize," and "this thing is great because it organizes everything." A second reason often cited for this text was the *easy access to information.* These responses included comments such as "allows you to flip back and forth to specific portions of the text more easily," "you can find the information you want more quickly," and "ease of switching among topics." Readers with the list electronic text most often cited the *easy access to information* provided by the overview as the reason for preferring this text. Readers with the traditional text preferring the electronic version most often justified their response by indicating that studying from a computer was *more enjoyable.* These comments included "it's more interesting to read via a computer," "studying [printed] books has become tedious and boring," and "didn't have to hold a book, just sit and look."

A series of z tests was also conducted on the proportion of readers shown in Table 2 indicating that their experimental text was more difficult than traditional printed text. This analysis indicated that significantly more readers judged the traditional text and list electronic text as more difficult than printed text relative to these judgments for the hierarchical electronic text. To determine what readers considered difficult about these two texts, the reasons given for the negative responses were categorized according to the nature of the problem indicated. For the list electronic text, the main reasons given for preferring traditional printed

text were *physical limitations* of reading from computers and *organizational difficulties* in structuring the information. Responses regarding physical limitations of computers indicated that reading from a computer was less comfortable than reading from a printed book (e.g., "must sit in the same position for a long time [with a computer]" and "computer bothers eyes"). Organizational difficulties included "harder to organize recall," "have to structure separate parts yourself as you read," and "text lost flow that normal text has." For the traditional text format, readers preferring printed text also cited the *physical limitations* of computers (as just defined) as well as a *lack of features* typically found in printed text. The latter included responses such as "lacked illustrations," "couldn't highlight," "couldn't take notes," and "harder to refer back to previous page." With the hierarchical electronic text, readers indicating that this text was more difficult were too few to classify their responses.

Discussion

The results of this experiment indicate that the hierarchical overview was easier to use, increased text review, and enhanced recall for unit title location relative to the list overview. It also resulted in better text summaries. Both overviews facilitated recall of unit titles and increased breadth of recall compared with the traditional text. These findings are now discussed.

Review Processes

The interactive text overviews were expected to increase text review by facilitating information search. As expected, readers were most likely to review with the hierarchical electronic text, but they were least likely to review with the list electronic text. Readers were less likely to review the list electronic text than the traditional text, even though readers had to skim sequentially through the traditional text to find information for review.

The list electronic text may have decreased text review, because it was relatively difficult to find information on this overview. On both initial reading and text review, readers spent longer searching for units on the list overview than on the hierarchical overview. Additionally, the organizational information inherent in the traditional text and provided in the hierarchical overview may have helped readers decide what to reread, possibly contributing to the tendency to review these texts.

Although fewer readers opted to review the list electronic text, readers who did review spent longer on the individual units than did readers of the hierarchical electronic text. This suggests that readers with the list electronic text were less willing to skim units casually during review. This result may again relate to the greater difficulty in locating specific units on the list overview. Readers who reviewed this text may have wanted to ensure that they would not have to reread

the unit again by processing it thoroughly on the first review. Another possibility is that readers with a better global text representation (provided by the hierarchical overview) were better able to read selectively as they reviewed the content within a unit, resulting in shorter unit review times.

The differences in ease of use of the list and hierarchical overviews may have been related to differences in memorability. Readers with both electronic texts recalled the unit titles equally well, but readers with the hierarchical overview were better able to recall title locations. This location memory would make it easier to find information, because readers would not have to search the overview for unit titles but could simply remember where the title was located.

Global Text Representations

As expected, fewer main ideas were included in summaries of the list electronic text than of the other text formats. This suggests that readers with this text had difficulty integrating the content of the units in a way that would enable them to determine the relative importance of specific information. There are two potential sources for this effect. First, the lack of organizational information in the list electronic text may have caused readers to process each unit as a stand-alone entity. In contrast, the hierarchical organization of the structured overview may have both helped and encouraged readers to form a representation of the content indicating relative importance across units. Second, independent of organizational differences, the observed differences in amount of text review could be responsible for differences in the summaries of the three texts. Because there was more review with the hierarchical electronic text and the traditional text, readers with these texts may have been better able to determine the main points from the texts as a whole due to their greater familiarity with the text content. This is also suggested by the correlational evidence that readers with the hierarchical electronic text tended to review the units having the greatest number of main ideas.

Local Text Representations

Readers with both overviews recalled information from more of the text units than did readers of the traditional text. This may reflect the better memory for the unit titles with these texts. In recalling the electronic text content, readers could have used their memory for the unit titles as recall aids, resulting in content from more units being included in recall. The electronic text format may have additionally produced less selective processing of the units than the traditional text, also resulting in greater breadth of recall. Because accessing each unit requires effort, readers may tend to process each unit they access to an equal degree, thus recalling at least some information from each unit read.

Although ability to recall unit titles may have contributed to breadth of recall, there was no difference in the total number of propositions recalled from the three texts. It may be that memory for the unit titles on the overviews prompted

recall only for units from which little was remembered, so that the effect on overall recall was small (and nonsignificant). For units from which readers recalled a great deal of content, memory for unit titles was probably superfluous. For units about which little was recalled, however, memory for the unit title may have enabled readers to recall the topic discussed and, in turn, prompt recall for some small amount of information about that topic. This would increase breadth of recall without substantially increasing overall amount recalled.

Reader Evaluations

Readers' evaluations of text usability were consistent with the hypothesized advantages and disadvantages of each text format. The hierarchical electronic text was judged as easier to use than traditional printed text because of the easy information access and the availability of organizational information that the hierarchical overview provided. There was not a clear-cut preference for the other two texts relative to printed text. Readers' responses indicated that they felt that these text formats had both positive and negative features. Readers of the list electronic text felt that this text provided easy access to information but hindered their ability to organize the text content and was less comfortable to use than printed traditional texts. Readers of the traditional text thought that studying from a computer was more enjoyable than using printed text but thought that the computer was less comfortable to use and lacked some useful features typically found in printed texts.

EXPERIMENT 2

In Experiment 1, the main advantage of using an interactive text overview was in the development of a more extensive text representation (including the information on the overviews), resulting in greater breadth of recall. The main disadvantage was that readers with the list overview did not integrate the text units in a way that would enable them to summarize the main ideas. Experiment 2 examined whether readers with a list overview would integrate electronic text content when given a learning goal requiring text integration. The materials and procedure were the same as in Experiment 1, but readers were given in advance the specific goal of preparing to write a summary of the main points of the text. It was expected that, with the explicit learning objective of summarizing, readers of all text formats would review to the degree necessary to organize and integrate the text units and to derive the main ideas. Therefore, the quality of the text summaries was expected to be similar for all three texts. Because readers given the list electronic text were expected to review at least as extensively as those given the other two text formats to meet the goal of summarizing, differences in text review found in Experiment 1 were not expected to be replicated. Readers with the list electronic text were expected to

review as much or more than readers with the other two texts in order to be able to write a good summary of the material.

Although differences in review strategies and text summaries found in Experiment 1 were expected to decrease with the specific learning goal, differences in the ease of use of the overviews were expected to be independent of learning goal, because differences in usability are inherent in the design of the overviews and not under the control of the learner. Accordingly, it was anticipated that readers would again find the list overview more difficult to use.

Method

Stimulus Materials

The practice and experimental texts were the same as those used in Experiment 1.

Participants

The readers were 63 undergraduates (three groups of 21 each) who had completed not more than one semester of college-level physics. This restriction on physics experience matched that of the readers in Experiment 1.

Procedure

The procedure was the same as that used in Experiment 1, except for the instructions. Prior to studying the texts, the readers were told that they would be writing a summary of the text after completing their study of the material. The instructions explained that the experiment concerned how students summarize information studied with a computerized text and that they would be writing a 10- to 15-sentence summary of the material that they read. They were told that their summary should include the ideas that were central to the text as a whole and that some units may contain several central ideas and other units may contain none. They were also informed that they would not be able to view the text while writing the summary. As before, readers first read the practice text and then the experimental texts, initially studying the units in the order specified (for the electronic texts) or as continuous screenfuls of traditional text. When they had finished the first reading of the text, they reviewed any segment of the text in any order. When they had completed their study, they were given the same tasks as in Experiment 1: (a) a summary, (b) a free-recall test, (c) a recall test for the unit names and locations (for the overviews) or the text headings and subheadings (for the traditional text), (d) a cued recall with the unit names or the text headings and subheadings as the cues, and (e) an evaluation of the usability of the experimental text. In this experiment, the length of the summaries was limited to 15 sentences instead of 25 sentences (as in Experiment 1), because no

one in the first study used the full 25 sentences, and it was thought that a stricter length limitation would encourage readers to be more selective in their summaries.

Results

As in the first experiment, the results are presented in four sections: (a) study and review processes, (b) global text representations reflected in the text summaries, (c) local text representations, and (d) reader evaluations. For measures analyzed with an ANOVA, comparisons of the means were done with the Newman–Keuls test with $p < .05$.

Study and Review Processes

Time required to use overviews. The average time spent on the overviews during the first reading of the text varied with text format, $F(1, 40) = 4.26$, $MSE = 3.19$, $p < .045$, with readers taking more time to find units on the list overview ($M = 5.40$ sec) than on the hierarchical overview ($M = 4.26$ sec). This effect was also found in the analysis of the review times, $F(1, 35) = 5.27$, $MSE = 42.91$, $p < .028$, with readers spending an average of 9 sec on the list overview and 4 sec on the hierarchical overview. These results confirm those from Experiment 1, suggesting that the list overview was more difficult to use.

Text study and review. Initial time on text and frequency and content of text review were analyzed in the same manner as in Experiment 1.

1. *Initial time on text.* As in Experiment 1, the total time initially spent reading the text units did not vary with format. Readers spent 10.39 min on the list electronic text, 10.71 min on the hierarchical electronic text, and 9.85 min on the traditional text.

2. *Proportion of readers reviewing.* In contrast to Experiment 1, there were no differences among the three texts in the proportion of readers reviewing at least one unit. The proportions of readers reviewing were .95 for the list electronic text, .90 for the hierarchical electronic text, and .95 for the traditional text. A series of z tests indicated no significant differences among these proportions. Thus, almost all readers reviewed at least some information, regardless of text format, when given the goal of summarizing.

3. *Proportion of units reviewed.* The average proportion of units reviewed by readers reviewing at least one unit was calculated for all three conditions. In the case of the traditional text, this calculation was made for the proportion of text screens reviewed. The 19 readers reviewing with the hierarchical electronic text reviewed an average of .77 of the units, whereas the 20 reviewing with the list electronic text reviewed an average of .61 of the units. The 20 readers who reviewed with the traditional text reviewed all the screens of text. Because the text screens reread could not be separated from those passed over during text search with the traditional text, only the review data for the two electronic texts

were analyzed. An ANOVA on the proportion of units reviewed by readers reviewing at least one unit did not reach significance, $F(1, 37) = 3.19$, $MSE = 0.084$, $p < .091$.

4. *Time spent reviewing text.* The average total review times for readers who reviewed were 173 sec for the hierarchical electronic text, 129 sec for the list electronic text, and 215 sec for the traditional text. An ANOVA on the total review times for each reader indicated that there were no significant differences among text formats.

Because readers differed in which units they reviewed, a multiple regression analysis was performed on the logarithm of the review times for each reader for each unit reviewed. As before, the data from the traditional text were excluded. The variables included in the analysis were the same as those in Experiment 1, but because readers in Experiment 2 often reviewed units more than once (i.e., went back two or three times to the same unit), a variable for review episode (1st, 2nd, 3rd, etc.) was also included in the analysis. Additionally, because it was expected that the effect of text format on review times would vary with the number of times the units had been reviewed, the interaction between text format and review episode was added to the variables in the analysis. Thus, the analysis included unit (which unit was selected), text format (hierarchical or list electronic text), review episode (1st, 2nd, 3rd, etc.), and the Text Format × Review Episode interaction. Reader was also entered as a categorical variable. The coefficients for the regression model (excluding the reader coefficients) are shown in Table 3. Because the units were entered as categorical variables, separate coefficients were obtained for each of the 9 units, as shown in Table 3.

TABLE 3
Parameter Estimates and Standard Errors for a Regression Model of the Log of the Review Times (in Seconds) From Experiment 2

Variable	*Coefficient*	*SE*	*p*
Intercept	1.162	—	—
Text format	–0.106	0.041	.01
Unit			
1	0.204	0.048	.01
2	0.065	0.051	.20
3	0.049	0.053	.36
4	–0.036	0.056	.53
5	–0.212	0.060	.01
6	0.241	0.048	.01
7	–0.229	0.061	.01
8	–0.054	0.058	.35
9	–0.029	0.052	.57
Review episode	–0.078	0.027	.01
Review Episode × Text Format	0.059	0.027	.03

Note. $R^2 = .39$; multiple $R = .63$.

Although the main effects of text format and review episode were significant, the coefficient for the Text Format × Review Episode interaction indicates that the effect of text format varied with the number of times the unit had been reviewed. Figure 2 shows the estimated unit review times for this interaction based on the coefficients from the regression analysis. On the first review of the text, readers with the list electronic text spent more time on each unit than those with the hierarchical electronic text, replicating the effect found in Experiment 1. However, the review times for the hierarchical electronic text were essentially constant across multiple readings of the units, whereas review times decreased for the list electronic text with multiple readings of a unit. This suggests that the different overviews produced different review strategies for the text. Readers with the list electronic text reviewed what they selected very thoroughly at first, possibly using subsequent reviews to check their understanding. Readers with the hierarchical electronic text reviewed by repeatedly skimming the units to the same degree on each rereading. As in Experiment 1, the coefficients for units show that some units were reviewed longer than others.

5. *Content reviewed.* As in Experiment 1, a correlation was performed between the number of readers reviewing each unit and the number of important ideas in the unit for the list and hierarchical electronic texts. These correlations, .15 for the list electronic text and .11 for the hierarchical electronic text, were not significant. Because this correlation was significant for the hierarchical elec-

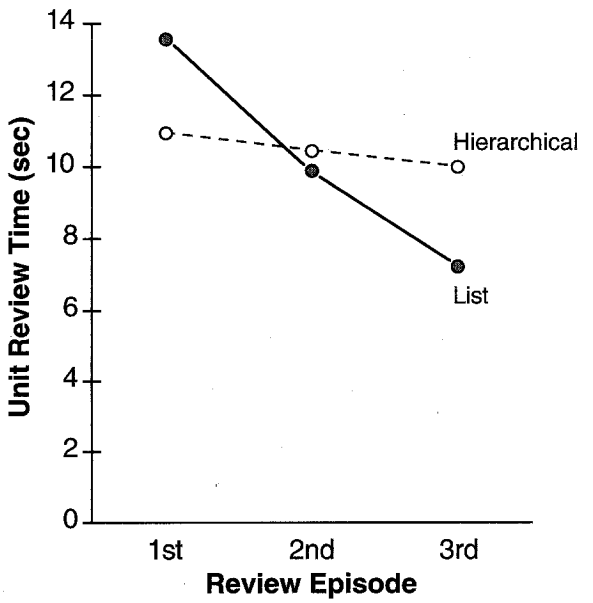


FIGURE 2 Estimated review times (based on Table 3) for the two electronic texts during the first, second, and third review episodes.

tronic text in Experiment 1, these findings suggest that review with the general learning goal was guided by the text content (i.e., information importance) to a greater degree than was review with the specific learning goal. It may be that readers with the goal of summarizing were basing their review on their assessment of the adequacy of their familiarity with the text as a whole so that they could write a representative summary of the entire text, rather than focusing on specific content.

Because readers in Experiment 2 reviewed units more than once, a correlation was also performed between the number of times a unit was reviewed and the number of important ideas in the unit. This correlation was also not significant for both hierarchical, $r = .25$, and list, $r = .36$, electronic texts.

Global Text Representation

The summaries were scored for the number of main ideas they contained, using the same scoring rules as in Experiment 1. A subset of 21 summaries was scored independently by two scorers, and there was 91% agreement as to which text propositions had been included in the summaries. An ANOVA on the total number of text propositions included in the summaries indicated no significant differences among the text formats in summary length. An ANOVA on the proportion of main ideas included in each summary also indicated no significant differences. The mean proportions of main ideas in the summaries were .57 for the hierarchical electronic text, .56 for the list electronic text, and .49 for the traditional text. Thus, when readers had summarizing as a specific goal, text format did not influence their ability to summarize the main ideas of the text.

Local Text Representation

Unit title recall. As in Experiment 1, recall of the unit titles was analyzed both in terms of readers' ability to recall the titles accurately and in terms of their ability to remember their location on the overview or text outline. Readers with the two overviews again recalled significantly more unit titles than did readers of the traditional text, $F(2, 60) = 8.38$, $MSE = 0.04$, $p < .001$. The mean proportions of titles recalled were .18 for the traditional text, .41 for the hierarchical electronic text, and .40 for the list electronic text. The analysis of the proportion of recalled titles whose location was accurately recalled indicated that the hierarchical electronic text resulted in better memory for title locations than did the list electronic text or traditional text, $F(2, 51) = 8.59$, $MSE = 0.11$, $p < .001$. These proportions were .44 for the traditional text, .69 for the hierarchical electronic text, and .26 for the list electronic text. These findings match those from Experiment 1, indicating that the greater attention given to unit titles with overviews increases recall of this information and that a spatial arrangement of the titles facilitates recall of their location as well.

Cued recall. The free and cued recalls were scored against a propositional analysis of the text for the number of text propositions recalled. Two scorers independently scored a sample of 21 of the recalls, and there was 94% agreement on which propositions had been recalled. As in Experiment 1, any propositions recalled on the cued-recall test that were also recalled in either the summaries or free recalls were eliminated from the analysis. An ANOVA on the number of additional text propositions recalled on the cued-recall test indicated no significant differences among text formats. The numbers of additional propositions recalled were very low: 2 for the hierarchical electronic text, 4 for the list electronic text, and 3 for the traditional text.

Free recall. The free recalls were scored for the proportion of text propositions recalled correctly and incorrectly. The scoring criteria were the same as in Experiment 1.

1. *Proportion of units in recall.* An ANOVA on the proportion of units from which at least one proposition was recalled indicated no difference due to text format in the proportion of units included in recall. These proportions were .83 for the hierarchical electronic text, .83 for the list electronic text, and .84 for the traditional text. Thus, when readers had the specific goal of summarizing a text, the text format did not affect the number of units from which they could recall information.

2. *Proportion of propositions recalled.* An ANOVA was performed on the proportion of propositions recalled in both the free recall and summary (excluding overlapping propositions). The number of recall errors was very low (an average of .07 of the recalled propositions were recalled incorrectly with the two electronic texts and .06 with the traditional text). Therefore, recall errors were included in the analysis of overall recall, as was done in Experiment 1. The results indicated no significant differences among the three text formats. The mean proportions recalled were .21 for the hierarchical electronic text, .19 for the list electronic text, and .18 for the traditional text.

3. *Proportion of propositions recalled per unit.* The mean proportion of propositions recalled by each reader from each unit included in recall was analyzed in the same manner as in Experiment 1. An ANOVA indicated no significant differences due to text format. The mean proportions of propositions remembered from each unit included in recall were .24 for the list electronic text, .25 for the hierarchical electronic text, and .22 with the traditional text readers.

Reader Evaluations

As in Experiment 1, readers were asked at the end of the experiment whether studying the text on the computer was easier or more difficult than studying traditional printed text and why. The proportions of readers stating that the

experimental text was easier to use, more difficult to use, or at the same level of difficulty as traditional printed text are shown in Table 4. A multiway frequency analysis on the number of readers judging each text as easier or more difficult (excluding readers who had no preference) indicated that the best fitting model was the saturated model including the interaction between text format and response.

A series of z tests on the proportion of readers in Table 4 indicating that the experimental text was easier to use than printed text showed that significantly more readers with the hierarchical and list electronic texts judged these texts to be easier than did readers with the traditional text. As in Experiment 1, readers of the hierarchical electronic text cited ease of determining *information organization* and *easy access* to specific information as their main reasons for preferring the electronic text over traditional printed text. Readers with the list electronic text also indicated these two reasons in explaining their preferences, even though this text did not provide explicit organizational information. In contrast, readers with the list text in Experiment 1 did not indicate any organizational advantage for this text. The comments of readers using this text in Experiment 2 focused on the utility of the list overview for helping them organize the information for recall. It may be that, with the summary goal, readers devoted more effort to imposing their own organization on the overview in deciding what to include in their summaries and thus found the list overview helpful in presenting a listing of the content for organization. Readers indicating that the traditional text was preferable to print text were too few to categorize in terms of their justifications.

A series of z tests on the proportion of readers shown in Table 4 judging the experimental text as more difficult indicated no significant differences among the three texts. Readers with both the hierarchical electronic text and traditional text cited as justification for this response the *lack of features* typically found in printed texts, such as the inability to take notes or highlight. In Experiment 1, only readers of the traditional text indicated that this was a problem. This suggests that readers with the hierarchical electronic text may have felt more of a need for these features when given the specific task of summarizing than with the general task of reading for an unspecified test. Readers with the list electronic text and traditional text also indicated that they were bothered by the *physical limitations* of reading from a computer (e.g., harder on the eyes, the need to sit upright), as was the case in Experiment 1. Unlike Experiment 1, however, readers

TABLE 4
Proportion of Readers in Experiment 2 Judging the Difficulty of Using Each Computer-Presented Text Format Relative to Traditional Printed Text

Computerized Text Format	*More Difficult*	*Easier*	*No Difference or No Opinion*
Hierarchical electronic text	.33	.57	.10
List electronic text	.33	.52	.14
Traditional text	.62	.14	.24

with this text did not indicate that they had organizational difficulties. This suggests that readers using the list overview felt that they were able to organize the text units adequately for the summary goal but felt a need for some organization inherent to the text presentation when faced with the general learning goal.

Discussion

This experiment compared study processes and text representations for the hierarchical electronic text, list electronic text, and traditional text studied with a learning goal emphasizing text integration. The results indicate that there are greater similarities among the three texts in both text review and internal representations with the specific goal as compared with the general learning goal in Experiment 1.

Review Processes

Text review was less strongly determined by the usability and organization of the overviews when the readers had the specific learning goal. In Experiment 2, there were no differences among the texts in frequency of text review, with almost all readers reviewing at least one unit and reviewing the same units multiple times. This was true even though the overview search times and title location recall confirmed the results of Experiment 1, indicating that it was more difficult to locate units with the list overview. Thus, readers with the specific learning goal expended the extra effort needed to achieve that goal through extensive review of all texts, including the list electronic text. With either learning goal, however, readers spent more time on their first review of the units with the list than with the hierarchical electronic text, suggesting that differences in overview usability have some influence on study strategy, even with a specific study goal. Additionally, the lack of organizational information with the list overview may have caused readers more difficulty in deciding what to focus on within the text units, resulting in longer initial review times.

The study strategies adopted by readers with the specific and general learning goals differed in several respects. Text review with the specific learning goal was more extensive, and there was no relation between units selected for review and unit content importance because readers reviewed the entire text fairly thoroughly. When given the specific goal of summarizing, readers with all three texts apparently tried to gain a thorough understanding of the complete text, which resulted in the use of similar review strategies across text formats. On the other hand, with the general learning goal, readers reviewed the texts that were the easiest to reread (opting not to review the list electronic text), and those who did review units reread them only once. In the case of the hierarchical electronic text, readers tended to review units containing the important ideas. This suggests that review under the general learning goal was guided to a greater extent than

under the specific learning goal by characteristics internal to the text (i.e., features of the text content and text format).

That readers reviewed the texts multiple times with the specific learning goal provides additional insights into review strategy differences between the two overviews. The readers with the list overview reviewed thoroughly on the initial rereading of the unit and then decreased reading times on subsequent reviews, whereas readers with the hierarchical overview continually reviewed at about the same level. This suggests that the list overview resulted in a more deliberate review-and-check strategy, whereas the hierarchical overview produced repeated skimming of the text content.

Global Text Representations

The summaries of the three texts in Experiment 2 did not differ in the proportion of main ideas included, indicating that readers were able to integrate content studied with the list overview. The results of Experiment 1 indicate, however, that this integration does not occur automatically. When reading for the general purpose of learning the text content, readers of the list electronic text had more trouble generating or recalling the main points than did readers of the traditional text and hierarchical electronic text. This may be attributable both to the lack of organizational information in the list electronic text and to the lack of spontaneous review with this text.

Given the specific goal of summarizing, review of the list electronic text increased to a level equal to that of the other two texts, and readers generated summaries similar to those of the other texts as well. This increase in review of the list electronic text may have reflected readers' effort to overcome the lack of organizational information by increasing their familiarity with the content through extra text processing. Readers of the hierarchical electronic text and traditional text also increased their text review with the summary goal, although not to the same extent as readers with the list electronic text. Because these texts were structured, however, the additional review may not have contributed significantly to the quality of their summaries. Rather than being necessary for achieving the study goal, review with these texts may have reflected readers' attempts to verify their understanding.

Although the readers knew that they would be required to write a summary in Experiment 2, the absolute proportions of main ideas included in the summaries of the hierarchical electronic text and traditional text were lower than those observed in Experiment 1. This most likely resulted from differences in interpretation of the summary instructions for the two experiments. In Experiment 1, readers were told after studying the text to write a summary including the main points of the text. At this point, they had already studied the texts and, therefore, had to draw on their available knowledge in generating the summary. In Experiment 2, readers were instructed prior to reading the text that they would be writing a summary of the text, including the ideas central to the text as a whole.

The study strategies adopted by readers in Experiment 2 involved repeated review of the entire text (rather than certain selected units), suggesting that they attempted to write summaries representative of the text as a whole, instead of including only selected, more important, segments. This is also indicated by the lack of correlation between the number of readers reviewing a unit and unit importance. Thus, the decrease in the absolute number of important ideas included in the summaries in Experiment 2 most likely reflects an attempt to write an all-inclusive summary based on recall from all units.

Local Text Representations

As in Experiment 1, the two electronic texts produced better recall of the unit titles than did the traditional text, and title locations were better recalled with the hierarchical than with the list overview. There were also no differences in the amount recalled from the three texts, again indicating that text format did not have a quantitative effect on the text representations. Unlike Experiment 1, however, there were no differences in breadth of recall among the three formats, with all texts producing recall from most of the available units. This most likely arose from the fact that readers reviewed all texts extensively and became familiar with all the text units, resulting in recall of some information from each. In this case, memory for the unit titles was not necessary in order for readers to recall the text topics, so the electronic texts did not have an advantage over the traditional text in this respect. Additionally, the overall greater breadth of recall with the specific learning goal may have been related to a smaller difference among the texts in the degree of selective processing of the content. Readers may have been more selective in the processing of the traditional text than the electronic texts with the general learning goal, but they attended to all units equally with all texts when given the summary task.

Reader Evaluations

Readers' subjective evaluations were similar to those in Experiment 1. Readers with the hierarchical electronic text again felt that this text provided easy access to information and aided in determining the information organization. With the summary goal, however, these readers also indicated that they missed some of the features typically found in traditional printed texts. This suggests that readers may have had more specific study strategies for the summary goal and thus missed the features provided by printed texts that support these strategies (e.g., note taking, highlighting). Readers of the list electronic text again noted that this text provided easy information access. However, they also felt that this overview provided useful organizational information, whereas in Experiment 1 readers indicated that they had organizational difficulties with this text. It may be that, with the goal of summarizing, readers were able to organize the text based on the requirements of the learning goal and thus were not bothered by the lack of

inherent structure. As in Experiment 1, these readers felt that the physical limitations of reading from a computer hindered study with this text. Readers of the traditional text also indicated that they disliked the physical limitations of studying from a computer, which is consistent with comments in Experiment 1. However, readers in Experiment 1 also stated that this text was more enjoyable than printed text, whereas this was not mentioned in Experiment 2. Readers were generally less satisfied with the traditional text format (compared with printed text) with the specific learning goal than with the general goal.

GENERAL DISCUSSION

The results of this research indicate that, for electronic texts, the format of the interactive overview interacts with the nature of the learning goal to influence both study strategies and the resulting text representations. Overview format influenced both text review and the ability to summarize the text content with the general learning goal. Additionally, with the general learning goal, both electronic texts resulted in more extensive text representations than did the traditional text.

Differences in Overview Usability

Regardless of learning goal, the list overview was more difficult to use, in that readers spent longer searching for units on this menu-like overview. Monk, Walsh, and Dix (1988) also found that readers worked more efficiently when hypertext unit titles were organized as a map rather than as a list. The hierarchical overview may have been easier to use because its spatial layout facilitated memory for the location of the unit titles. The unit titles on this overview formed a two-dimensional tree structure on the screen; the titles on the list overview were simply higher or lower in the list and, thus, less spatially distinct. Billingsley (1982) reported similar results in a comparison of a hierarchical content map and a linear index of menu choice sequences. Although both types of overviews were initially equally effective for information location, the hierarchical map facilitated the development of a mental model of the text structure that was better retained (as indicated by information location performance). Billingsley concluded that the spatial features of the map aided memory for how the text components were interrelated. The results of this research suggest that one central difference between good and poor overviews is the degree to which the spatial layout of the titles facilitates memory for their location.

Study Strategies

As with traditional text, readers of electronic text were generally strategic in their text study. This is consistent with studies showing that even middle school children quickly develop task-appropriate strategies for using electronic texts

(Rouet, 1991; Wright, 1991). However, the extent to which readers altered study strategy with learning goal and the nature of their strategies varied with the overview format.

With the general reading goal, readers with the list electronic text appeared to be less strategic than did readers with the other two texts. They tended to read it just once, apparently not forming any review strategy based on their initial reading. Thus, even though these readers indicated in their evaluations that they felt the easy access provided by this overview was an advantage, they did not exploit this feature to review. Those who did review spent a relatively long time on the units they reread, suggesting that they were rereading entire units rather than strategically searching for particular information or main points. In contrast, readers with the hierarchical and traditional texts were more willing to review with the general learning goal (i.e., more readers reviewed), suggesting that it was easier to adopt a review strategy with these texts. This is consistent with research by Hammond and Allinson (1988) indicating that learners prefer maplike overviews over index listings for general browsing with hypertext.

The list electronic text may have inhibited text review relative to the other texts due both to the difficulty of using the list overview and to the lack of organizational information. Lacking guidance for review from either a learning goal or structural information, readers may have been reluctant to expend the additional effort required to develop a strategy for reviewing this text. This is consistent with readers' comments indicating that they had difficulty organizing the content with this overview in Experiment 1 (but not with the specific learning goal in Experiment 2). Other research has reported similar findings that readers use topic lists less actively than other forms of navigation tools (e.g., spatial maps and guided pathways) when learning from a hypermedia system (Trumbull, Gay, & Mazur, 1992). Additionally, relatively small variations in the visual layout of hypertext access facilities have been shown to influence the degree to which they are used (Wright, 1991). These findings suggest that the overview design considerably influences the extent to which readers take advantage of the flexibility provided by interactive overviews for browsing unfamiliar content.

With the specific learning goal, all readers reviewed all units extensively, regardless of text format. There was no correlation between amount of review and the importance of the unit, suggesting that readers attended to the units equally in determining how best to summarize the text as a whole. This difference in processing strategy between learning goals is consistent with research with traditional text indicating that readers adjust the attention they give to the topic structure of a text according to the demands of the learning goal. Readers will focus more on topic-related information when this is an important component of the learning objective (Lorch, Lorch, & Mogan, 1987; Schmalhofer & Glavanov, 1986). In the current research, readers with the summary goal were more thorough in their text processing, reflecting the need to develop a good macrostructure representation for the text as a whole in order to summarize the text.

Text Representations

Differences among the texts in the internal representations developed for the content were most prominent when readers studied with the general learning goal. At the local level, the general learning goal resulted in greater breadth of recall with the two electronic texts than with the traditional text (i.e., the recalls included more units), even though the list electronic text was reviewed less extensively. This effect may arise both from better recall of the unit titles and from less selective text processing with the interactive overviews.

The electronic texts produced better recall of the unit titles than the traditional text, a finding paralleling that of chapter heading recall with SuperBook versus printed text (Egan et al., 1989). This was most likely due both to the format of the titles (separate from the text proper) and to the way they were used (to access information). The electronic texts also increased breadth of recall, reflected by the number of topics for which readers could remember some information. In recalling the text content, readers could have used their memory for the unit titles as recall aids, resulting in recall from more text units. This would be consistent with the results of research by Lorch and Lorch (1985) on the effects of text topic structure on memory for text (see also Lorch, 1989). Lorch and Lorch found that structural overviews (i.e., introductory paragraphs presenting the text topics and their organization) increased the number of text topics readers included in recall but did not affect the amount recalled about each of these topics. They proposed that readers use their topic-structure representation to guide text recall, so that readers with a better topic representation are able to retrieve information about more text topics when recalling a text. In the current research, both interactive text overviews facilitated memory for the unit titles and increased the number of topics included in recall (i.e., for which some content was remembered). This provides support for Lorch's proposal that readers retrieve topic information and use this to guide text recall when it is available. These results suggest that interactive text overviews can function as retrieval aids by increasing memory for the topics presented in the text in a manner analogous to that of introductory structural overviews for traditional text.

In addition to reflecting better recall for the text topics, the greater breadth of recall with interactive text overviews may be due to less selective processing of the text units. With an interactive overview, readers may assume that each unit is important or it would not be on the overview (Landow, 1989) and, thus, initially treat all units as roughly equivalent in importance. In contrast, readers with traditional text who are reading the units continuously may be more likely to assume that some units are introductory or provide incidental elaborations and may devote less attention to the content of these units, resulting in readers being able to recall content from fewer text units (Anderson, 1982; Dee-Lucas & Larkin, 1988).

At the global level, readers with the general learning goal included more main ideas in summaries of the hierarchical and traditional text than in those of the

list electronic text. To identify the main points in a body of information, readers must integrate the content into a unified representation so that they can determine the central ideas in the context of the entire text. The results of this research suggest that readers with a list overview do not integrate electronic text units in this way unless required to do so. Other researchers have similarly reported detrimental effects of hypertext formats on the acquisition of main ideas. Gordon, Gustavel, Moore, and Hankey (1988) found that participants given general learning instructions performed better on questions regarding text macroconcepts when they studied traditional text rather than an embedded hypertext (i.e., with highlighted words linked to text segments of greater detail and/or less importance). This result is also consistent with research with traditional text investigating the effects of good and poor structure on readers' ability to identify main ideas (W. Kintsch et al., 1977; W. Kintsch & Yarbrough, 1982). Research with traditional text indicates that poor or incomplete text structure can result in poor macrostructure representations unless readers devote the additional effort needed to structure the material for themselves (E. Kintsch, 1990; Meyer et al., 1980).

In the current research, the poorer quality of the summaries with the list overview may be related both to the lack of processing guidance from the general learning goal and to the absence of explicit text structure. The hierarchical overview indicated the superordinate–subordinate relations among units, thus both encouraging readers to think about the interrelations of the units (Salomon, 1988) and providing information about how they were related. However, differences in the ability to summarize the texts may also be related to differences in study strategies. There was less review with the list electronic text than the other two texts, so that readers with this text were less familiar with the text content. Although there were no differences in the amount recalled from the texts, differences in depth of understanding due to the additional review may have enabled readers with the hierarchical and traditional texts to generate an unanticipated summary that better reflected the main points of the text.

The potential problem with text integration in electronic texts such as hypertext has been labeled a "cohesion deficit" problem, arising, first, because information can be studied in a less than optimal order and, second, because there are few rhetorical devices to link information into a coherent whole (e.g., transitional devices, signals of importance; see Duchastel, 1990, for discussion). As noted earlier, the interrupted nature of text study intrinsic to using an interactive overview could also contribute to a lack of cohesiveness. Duchastel speculated that a cohesion deficit could have beneficial effects on comprehension because the extra processing required to overcome this deficit would produce better retention and a more thorough understanding of the material. This would result in a comprehension advantage compared with traditional text. However, if readers do not devote the extra effort required to interrelate the information without textual cues or are unsuccessful in their attempts, this will produce a fragmented representation of the information that would interfere with retention.

Some empirical support for this proposal comes from research with traditional text indicating that, in some circumstances, increasing the processing difficulty of text can increase depth of understanding. For example, E. Kintsch (1990) had skilled readers summarize a text having either a good or poor macrostructure (with the topic structure disrupted but local coherence maintained) and found that the poorly organized texts resulted in higher quality summaries. She suggested that these readers worked harder to reduce the information into a good summary, thus resulting in more constructive text processing. Similarly, Mannes and W. Kintsch (1987) found that readers displayed a deeper understanding of text content when its organization differed from related prior learning as opposed to having a similar structure. Readers with the differing organization performed better on inference verification and problem-solving tasks but more poorly on recall tasks compared with readers given a consistent text structure. This area of research suggests that text manipulations that induce readers to process the text more thoroughly (by requiring readers to interrelate the content more thoroughly within the text and/or with related prior learning) can enhance understanding, but possibly at the expense of veridical recall.

Our results indicate that, without a specific learning goal, readers with a list overview have difficulty integrating the text units and do not spontaneously engage in the additional processing required to overcome this difficulty. Thus, the cohesion deficit due to the lack of explicit structure results in a poorer text representation in these circumstances. With the specific goal of summarizing, readers with the list overview are able to overcome the difficulty through additional processing of the text (i.e., repeated review), so this is not an insurmountable problem. However, there was no evidence in this study of a beneficial effect of the increased processing difficulty associated with the list overview: Extra processing of the list electronic text did not produce any retention benefits relative to the hierarchical and traditional texts. This may have been because readers with both of the latter two texts spontaneously reviewed and reprocessed the texts, so that they also processed the material very thoroughly. An increase in the processing difficulty of the text resulting from the list overview could only have a positive effect on memory if it increased the depth of processing beyond that of the other text formats (Einstein, McDaniel, Bowers, & Stevens, 1984). The findings of research on the effects of processing difficulty with traditional text suggest, however, that the extra processing with the list overview could have had beneficial effects on readers' depth of comprehension that were not reflected in the dependent measures used in this research.

CONCLUSIONS

The results of this study confirm the critical role of the design of the overview in determining how and what readers learn from electronic texts. The findings suggest that the extent to which readers take advantage of the flexibility of these

texts to explore new content depends on the ease of use of the overview and on the relational information it contains.

The results suggest that electronic texts with interactive overviews provide some learning advantages over traditional text, particularly when readers' objective is to become generally familiar with the subject matter. Both electronic texts produced better memory for the text topics and the inclusion of more of these topics in recall of the text as a whole. Thus, electronic text with an appropriate overview has beneficial effects on incidental memory and breadth of recall for the text. Furthermore, this research suggests that, when overviews provide structure for the text units, the electronic text format does not interfere with the representation developed for the text (Charney, 1987, 1994; Jonassen, 1986). Because this research ordered the material for the first reading, however, this finding can generalize only to situations in which readers can, either on their own or with the help of organizational aids, order the content appropriately for initial study.

The main disadvantage of electronic texts is that they may result in a fragmented representation of the text content when readers do not have a specific learning goal, unless there is some explicit support for text integration (such as an organized overview of the units). This finding argues for including organizational aids in electronic texts to help readers structure the information appropriately. Maintaining coherence among information units is widely recognized to be a potential problem in using hypertext, and various solutions have been proposed (e.g., Hammond & Allinson, 1988; Marshall & Iris, 1989). The extent to which this poses a problem for readers depends, however, on the purpose for which the text is being used. Readers prefer different types of navigation systems for different tasks and text organizations with hypertext (Wright & Lickorish, 1990). Our study suggests that minimally structured overviews that allow students to impose their own organization on the information may not be appropriate when students are gaining an overview of a new topic but could be used profitably when students have specific tasks guiding their learning.

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