The Comprehensibility of Linear versus Nonlinear Documents
by Carol S. Isakson and Jan H. Spyridakis

Abstract

We examine comprehension research that suggests readers must have some degree of familiarity with a document's topic and structure to instantiate appropriate schemata. Given the effect of schemata on reading comprehension, we question whether nonlinear formats allow readers to instantiate schemata. We conclude that research must be conducted to assess the use of reading strategies in non-linear environments.

Introduction

When people read words and sentences from any source, they do so in a linear fashion and comprehend the ideas in a hierarchical fashion. For years, technical communicators have relied on research from a variety of disciplines, research investigating paper and electronic documents that have been arranged in a linear fashion due to the limitations of the media. Not only have these documents been linear, but they have been designed for readers and users who are assumed to process information in a hierarchically related fashion (McKoon, 1977; van Dijk and Kintech, 1983). Given the advent of hypertext, and modular documents such as on-line help and alphabetic software documentation (Prekeges, 1988; Slivinski, 1988; Grimm, 1988), and our need to effectively deliver information to different audiences, we must now answer the following questions.

- Do reading strategies, delineated in existing research studies of linear documents, accurately reflect a reader's behavior with and comprehension of non-linear documents?

- Do non-linear documents work for all types of information?

This article examines reading models and then focuses on comprehension research, specifically research on the effect of prior knowledge and schemata, that suggests that readers must have some degree of familiarity with the topic and the structure of the document at hand to be able to instantiate an appropriate schema with which to assimilate new information. Further, using this research base, we discuss non-linear documents and their wide-range applicability. Finally, we cite the need for research conducted on non-linear documents to assess established comprehension principles developed from the mass of reading research.

Reading Models

Many models of reading and comprehension acknowledge the influence of the reader's pre-existing knowledge on the reading process. It is interesting to note that all reading models attempt to represent the process of reading and comprehension as one of imposing order on incoming stimuli or one of building structure (Gernsacher, Hargreaves, and Beeman, 1989; Goodman, 1978; Gough, 1972; Kintech and van Dijk, 1978; Meyer, 1984; Stanovich, 1980). Whether the model is bottom up, suggesting readers work from words to long term memory (LTM), top down, suggesting readers work from LTM to individual words in the text, or interactive, suggesting readers use a mix of bottom up and top down processes, few actually examine comprehension. Kintech and van Dijk (1978) assert that comprehension follows the reading process and entails (1) selecting a set of propositions to hold in short term memory (STM), (2) processing a second set of propositions, (3) attempting to link the two proposition sets, (4) accessing LTM to link the propositions if linking in STM fails, and (5) creating inferential links if necessary. The linkages formed in steps three through five are critical if readers are to comprehend and apply the information they take in during reading. Although Kintech, Welsch, Schmalhofer, and Zimny (1988) recently updated this classic model to further explain how readers comprehend and integrate text based information into their own knowledge bases, their new model still describes how readers generate macropropositions from the text and rely on retrieving knowledge from LTM.

Prior Knowledge and Schema Theory

The reading models discussed above maintain that readers' knowledge will interact with their reading and comprehension processes. Readers' prior knowledge structures should facilitate readers in selecting text based information to store in memory, in linking new information with old information already present in memory, and in providing ideological anchors (Ausubel, 1968; Afferbach, 1990; Fincher-Kieser, Post, Greene, and Voss, 1988). These knowledge structures are often called schemata—abstract scaffolds with slots or placeholders that can be instantiated with specific bits of information. A general definition of schemata states that readers' schemata are equivalent to their expectations: what readers expect from a text will influence what they take in and retain from a text, how they interpret the text, and how they organize that information in memory. Piaget hypothesized that meaning occurs when the learner...
assimilates new information into an existing schema (Prince and Mancus, 1987). Meaning does not appear to occur unless one of three possibilities exists: (1) the new information fits an existing schema; (2) the existing schema framework can be altered to contain the new information; or (3) a new schema can be built to accommodate the information (Whitney, 1987).

According to schema theory, individuals build schemata based on knowledge they have acquired in the past. Reading research on schema theory has examined several kinds of knowledge readers use to build schemata to comprehend written text. In particular, researchers have looked at the effect of content and structure schemata based on readers' prior knowledge and culture.

Content Schemata

Content schemata stem from readers' knowledge about the topic at hand. Content schemata have been found to help readers infer implicit relationships, acquire new information, and guide interpretation of text-based information. Studies of content schemata have found that readers face problems when calling up an inappropriate schema, attempting to instantiate information into an inappropriate schema, or allowing information from an inappropriate schema to intrude into the comprehension of a text. Most content schemata studies focus on prior knowledge schemata while a few focus on culturally based schemata.

Researchers of schemata based on prior knowledge have generally examined the effects of strong versus weak or no schemata. Pearson, Hansen, and Gordon (1979) investigated readers who possessed strong or weak schemata for a topic and concluded that readers with strong schemata were more able to infer implicit relationships. Recht and Leslie (1988), grouping subjects by strength of schemata, found that strong prior knowledge overrode text-based information and that when prior knowledge was compatible with the text, there was no facilitatory effect. Anderson, Reynolds, Schallert, and Goetz (1977) found that subjects injected more schema based information into a passage for which they had strong prior knowledge. Over 80% of their subjects were unaware of an alternate interpretation of ambiguous passages, indicating that the readers' schemata activated at a high enough level to eliminate consideration of other interpretations. Lipson (1982) found that readers familiar with textual information were better at acquiring totally new information than correcting inaccurate old information. Further, subjects with no prior knowledge performed better than subjects with inappropriate prior knowledge. Alvermann, Smith, and Readence (1985) found the comprehension of readers who had activated compatible knowledge before reading to be quite similar to that of readers who had not activated prior knowledge. However, prior knowledge that was incompatible with the text interfered with the reader's comprehension of the correct information in the text.

Many researchers have noted the profound influence that a content schema based on cultural knowledge can exert on an individual's comprehension. Steffensen, Joag-Dev, and Anderson (1979) compared the performance of readers from different countries (India, U.S.) and found a significant interaction of nationality and passage with each cultural group performing best (recalling more idea units and reading more quickly) with a passage from its own culture. When reading passages based on other cultures, each cultural group made more errors in elaborating idea units and constructed inappropriate schemata based on content schemata from its own culture. Lipson (1983), defining culture in terms of religious affiliation (Catholic, Jewish), found that readers relied on culture based content schemata appropriate to their religious background. Subjects took less time to read a culturally familiar passage and recalled more correct information and more explicit and inferred information from the culturally familiar passage. Reynolds, Taylor, Steffensen, Shirey, and Anderson (1982) examined the effect of race (black, white, and residence (urban, rural) on content schemata and found that readers interpreted passages based on their own cultural schemata—schemata that were intrusive for those with an inappropriate cultural schemata.

Readers' content schemata based on strong prior knowledge and cultural influences have been shown to both facilitate and impede comprehension. Further studies have been conducted on structure schemata.

Structure Schemata

Structure schemata stem from a reader's knowledge about text structure and may be based on prior knowledge and on cultural background. Structure schemata have been shown to assist recall, improve comprehension, facilitate the identification of document coherence, and activate themselves automatically.

Brooks and Dansereau (1983) examined the effectiveness of (1) using structure schemata as an aid in organizing text and (2) training students to use structure schemata as an aid in processing text. Generally speaking, teaching the use of structure schema theory and organizing text according to structure schema theory assisted recall. Roller (1985) found that prior knowledge about content and structure influenced readers differently, depending upon their goal. While content schemata significantly affected the readers' perceptions of the importance of information in one study, structure schemata significantly affected readers' summaries from the passages in a second study. The findings suggest that readers' goals influence whether they determine the importance of information based on content or structure schemata. Finally, Olhausen and Roller (1988) examined the integration of structure and content schemata. Results indicated that when readers could use content schemata, they did not make full use of structure.
schemata. Further, readers tended to use their structure schemata in an automatic, unconscious way, and in a different way on difficult passages—they attempted to use structure schemata whether it was possible or not. The findings suggest that, with well structured text (both content and structure schema based information is available), readers use content schemata more consciously than structure schemata. The effects of structure schemata can also be seen in studies of cultural schemata.

McClure, Mason, and Williams (1983) investigated the culture based structure schema that readers develop for the sequence of events within stories. They found that different cultural groups used different strategies for making the narrative coherent, and for choosing initial and final sentences in stories. Readers who lacked the schema used in a given story exhibited poorer comprehension because of the mismatch between the reader’s and the story’s structure schemata.

Familiarity with structure has also been shown to be useful for carrying out procedural operations. Kieras and Bovair (1984) trained subjects in procedures for operating a device—some subjects were trained by rote and some learned a model of the device and then were trained by rote. Subjects who were familiarized with the device model learned the procedures more quickly, inferred the procedure more easily, and exhibited better recall than subjects who were not familiarized with the model of the device.

Comprehension of Non-linear Documents

While we would ideally like to draw strong conclusions about the comprehensibility of non-linear documents from the reading literature, we can only make inferential leaps. Clearly, more research on known comprehension factors must be conducted in non-linear environments. However, the reading/comprehension models reviewed at the beginning of this paper and the research findings presented on the effects of content and structure schemata do reveal that readers form linkages among textual information units based on information structures previously stored in LTM. When such information structures are compatible with a text, they facilitate a reader’s interpretation and recall of text based information yet when they are incompatible, they supersede text based information.

Given the influence of readers’ schemata on interpreting and linking information in linear documents, one must question how readers or users of non-linear documents identify relationships, particularly if the information itself is not encyclopedic in nature. We know that readers who possess strong structural knowledge perform better with well structured texts than with unstructured texts, while readers without strong structural knowledge perform poorly with both structured and unstructured texts (Taylor and Samuels, 1983). Research has shown that readers of poorly structured hard copy and on-line text show increased reading times for topic sentences and reduced overall recall; however, in some instances clear overviews of the text’s topics improve the recall of even unstructured texts (Lorch and Lorch, 1985; Lorch, Lorch, and Matthews, 1985). We also know that readers who can rely on an author’s structure and signaling of it demonstrate superior performance (Spyridakis, 1989 a, b). We further know that readers who cannot bring their structural knowledge to bear will exhibit recall patterns of poor comprehenders—a recall pattern that will appear to be a rote listing of equivalent information units (Wenger, 1989; Wenger and Spyridakis, submitted for publication). The levels effect so critical to good reading, where superordinate and subordinate idea units are distinguished and hierarchically organized, will not appear.

While the needs and strategies of readers or users of linear and non-linear documents may be similar, non-linear documents cannot function similarly to structured texts, as they are, by their nature, unstructured. Although the lack of such structures may not impede the user of a non-linear reference document (e.g., a dictionary, an encyclopedia, or an on-line help file), the current trend in the hypertext and non-linear document movement is towards the belief that many information types for multi-purposed users can be adapted to a non-linear environment. We must acknowledge that a reader’s purpose or intention will significantly influence how that reader interacts with any document.

Some researchers have recognized the existence of the similarity of readers’ needs in linear and non-linear texts (Hendry, 1989; Smith, Weiss, Ferguson, 1987; and Prekges, 1988). Smith et al. (1987) indicate that readers of hypertext are susceptible to the same comprehension problems as readers of traditional text and that features that facilitate comprehension in traditional texts are apt to assist hypertext readers. Gerhard Fischer (Fischer, Jones, Kinstch, Kay, Trigg, and Weyer, 1988) suggests that users of hypertext face the constant need to restructure information. One must question whether readers are capable of this continual restructuring. Prekges (1988) warns that designers of alphabetic references must not split the topic into too many small pieces or users will be forced to move back and forth among topics to obtain required information. However, if designers combine related topics to create larger units, they defeat the purpose of an alphabetic reference.

The goal of hypertext and non-linear documents is to surpass the limitations of linear text; however, the major limitation that they surpass—that of explicit structure and pre-established relationships—may actually create great difficulties for users. One could defend a lack of structure in non-linear documents and the difficulties that the missing structure can cause for readers by maintaining that readers could rely on content schemata.
Prekeges states that designers may neglect to include relevant topics, creating information gaps. Further, he states that designers must use terminology with which users are familiar, if the user has any hope of identifying a relevant content schema. While only research can tell us whether users of nonlinear documents can rely on content schemata in the absence of structure schemata and whether familiar terminology is sufficient to help users access content schemata in non-linear environments, one must question how users who are unfamiliar with the content base of a given non-linear document would perform.

Research is critically needed that investigates how and whether users identify logical connections in non-linear documents and whether their comprehension reflects an understanding of superordinate and subordinate relationships. Furthermore, such research must be conducted with a variety of users who possess strong and weak content and structure schemata and with dependent measures that actually reflect comprehension. When such research has been conducted, we will know whether our view of reading strategies, stemming from research studies of linear documents, accurately represents a reader's behavior with and comprehension of non-linear documents.

References


Carol Isackson, a graduate student in the Department of Technical Communication at the University of Washington, teaches advanced technical writing through the College of Engineering, the College of Forest Resources, and the University Extension Service. She has also worked as a Research Assistant in the Human Factors and Organizational Effectiveness division of Battelle Human Affairs Research Center.

Dr. Spyridakis is an Assistant Professor in the Department of Technical Communication at the University of Washington where she teaches courses in Style in Technical Writing, Special Documents, Understanding Research, and Conducting Research. Her primary research interest is in document and screen design variables.