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Abstract

With the growth of the Internet and web-based instruction, we find ourselves more and more living and communicating in a hypermedia world. The following provides a theoretical basis for understanding how people learn from the web. It also describes original research on the contribution of graphics and hyperlinks to recall and retention of information presented in web-based instruction.

Introduction

Web-based instruction differs from traditional textbooks in at least two important respects. One of those respects is its ability to use multimedia elements, such as audio and video, as well as still graphics. At current modem speeds, even the use of still graphics slows transmission. Are graphics worth their wait in aiding communication?

The other, and more dramatic, difference of the Web is its use of hypermedia. Hypermedia is the technology that allows readers to click on a word or picture to jump from story to story. Hypermedia at its best can enhance communication by allowing readers to pursue information along any lines. At its worst, "hypermedia documents can be disorienting to readers . . . [and] leave readers wondering what they've missed" (Beekman 1994). Do hypermedia links enhance or hinder communication?

Episodic Memory and Mental Nodes

Remembering has been related to what is called episodic memory (Woodall et al. 1983). Episodic memory stores information along with the context in which that information was presented or encountered. Research has shown that contextual cues, such as graphics, can be effective retrieval aids for memory recall (Woodall and Folger 1981).

Understanding, on the other hand, is related to semantic memory, which has been described as a network of linked words or concepts. "For example, the node 'DC-10' might be linked to the node 'airplane' by a class relationship, and to the node 'accident' by time and place relationships" (Woodall et al. 1983). In other words, new information is linked to interpreted information in terms of pre-existing knowledge. Although different from remembering, understanding can facilitate remembering according to Woodall et al. because the mental nodes serve as cues.

Coherence vs. Cognitive Overhead

The trick is to build the mental nodes as a clear structure rather than a Tower of Babel. Two mental processes that operate in opposition to each other are coherence and cognitive overhead. "A document is coherent if a reader can construct a mental model from it that corresponds to facts and relations in a possible world"(Thuring et al. 1995).

Thuring et al. note that in hypermedia documents, coherence is a positive influence and cognitive overhead is a negative influence on comprehension. Coherence is what allows a reader to construct a mental model from the story. Hypermedia can help provide the structure for coherence. Coherence in a document could help build a node structure for semantic memory. However, hypermedia can also add cognitive overhead by requiring additional effort and concentration to mentally maintain the linked trail.

A Study of Graphics and Hypermedia

Research conducted by the author attests to the struggle between coherence and cognitive overhead and underscores the value of graphical cues. Ninety-eight participants read one of four versions of a news story presented through a Web browser. Two-thirds of the sample were enrolled in beginning computer literacy classes, making the sample heavily oriented toward beginning computer users.

A newspaper story on satellite television services was modified and coded into HTML. The story as presented was approximately 700 words in length. In the hypermedia versions, 115 of these words were broken out into a linked page on the RCA DSS system, and another 106 words were broken out into a linked page on the Primestar system. The Graphics-No Hypermedia version included a picture of the RCA DSS dish and a picture of the Primestar dish. The Graphics-Hypermedia condition also included these two pictures plus graphics of the RCA and Primestar logos in the linked pages. It was hypothesized that the use of graphics and hypermedia links would significantly increase both immediate recall and longer-term retention of information.

Results

Participants completed a 15-question quiz immediately and again after one week. The average scores reported in Table 1 show that the subjects who read the story with both graphics and hypermedia links did the best, both immediately and after one week. Surprisingly, the subjects who read the story with hypermedia links but without graphics did the worst. All scores declined over the week. However, the scores for the subjects who read the story with both graphics and hypermedia declined the least amount.

Table 1. Average Scores

	Immediate Recall		One Week Retention	
	No Graphics	Graphics	No Graphics	Graphics
No Hypermedia	7.39	8.08	5.61	6.25
Hypermedia	7.12	8.55	5.08	7.60

Analyzing the results using analysis of variance (ANOVA) showed that, for immediate recall, none of the differences were statistically significant at the .05 level (Graphics: $F[1,94] = 3.04$, $p < .10$), (Hypermedia: $F[1,94] = 0.002$), (Interaction: $F[1,94] = 0.40$). The results after one week show no significant effect for the use of hypermedia ($F[1,94] = 0.21$) but a statistically significant effect for graphics ($F[1,94] = 6.55$, $p < .05$). The interaction effect of hypermedia and graphics scored fairly high following one week, but fell well short of significance ($F[1,94] = 2.59$).

Conclusions

The hypotheses were only partially supported. The study indicates that the use of graphics in web-based training aids the retention of information. However, it is perhaps even more relevant that the use of hypermedia did not increase recall or retention. Hypermedia links separated information about the DSS satellite system from information about the Primestar satellite system. The links should have provided cognitive nodes for understanding and retaining the material. However, that did not happen, possibly because, for these computer beginners, the positive influence of coherence was outweighed by cognitive overhead (i.e. keeping the hyperlinked path in mind, scrolling through the story, etc.).

Experienced web users might not have experienced as much cognitive overhead and exhibited a different level of recall and retention. This could be followed-up in future research. A follow-up study might include specific follow-up questions to quantify subjects' levels of coherence and cognitive overhead.

Research could also investigate if coherence and cognitive overhead could be manipulated by placing the hypermedia links in different positions in the document. The research reported above placed links in the middle of the story. Perhaps moving the links to the end or to a frame to the left of the content would increase coherence.

In the meantime, creators of web-based training should be encouraged to include graphics as an aid to communication. Even still graphics can enhance the retention of information, possibly because they provide episodic memory cues to help readers later recall the information. However, web masters should consider carefully how they use hypermedia links. Hypermedia may in some cases or with some people actually reduce recall and retention. Further research is needed. For better or worse, web-based training is here to stay. We had better learn how to use it effectively.

References

Beekman, G. (1994). *Computer Currents.* Redwood City, CA: The Benjaman/Cummings Publishing Co.

Thuring, M., Hannemann, J., & Haake, J. M. (1995) Hypermedia and cognition: Designing for comprehension. *Communications of the ACM,* 38(8), 57-66.

Woodall, W. G., Davis, D. K., & Sahin, H. (1983). From the boob tube to the black box: Television news comprehension from an information processing perspective. *Journal of Broadcasting,* 27 (1), 1-23.

Woodall, W. G., & Folger, J. P. (1981). Encoding specificity and nonverbal cue context: An expansion of episodic memory research. *Communication Monographs,* 48, 39-53.