HCI Hypermedia

Andrew Dillon
HCI Lab
SLIS
Indiana University
Bloomington IN 47405
adillon@indiana.edu

Usability Issues in Hypermedia

---

1. Introduction

Hypermedia is a general term used to describe the presentation of graphical, textual, audio and video information in nodes (chunks) that can be linked together and accessed in a manner determined by the immediate interests of the user. Originating as an idea for mechanized information access and organization that better reflected the natural workings of the human mind by Vannevar Bush (1945), the potential of the computer to provide the best means of supporting hypermedia was recognized early on by thinkers such as Ted Nelson and Doug Engelbart (for a historical overview see Conklin, 1987). The move toward hypermedia-based digital documents holds with it the promise of user-controlled, immediate access to the world of published information and stored data. While originally a specialist application domain, in the last few years the World Wide Web has brought to everyone's desktop the power and problems of hypermedia interaction. Yet from the outset, human factors researchers have noted a range of user issues that prevent the simple transition from analog to digital resources

2. The range of human factors concerns with hypermedia

Relevant research on the subject of interface design for information access in electronic domains began several decades ago but it is only in the last 15 years or so that the

technology existed to support empirical research into hypermedia interfaces. Since then, there has been an explosion of studies examining such standard user performance issues as speed and accuracy of screen reading, the design of navigation aids for information spaces, the combinatorial value of images and text for information exploration, and the educational value of hypermedia information.

Dillon (1994) reviewed the ergonomic literature on digital documents and reported findings on the outcome and process differences between digital and analog documents at the physical, visual and cognitive levels. Since then, interest in the social aspects of hypermedia creation and use has also blossomed and there now exists a large and sometimes contradictory research literature on the human factors of hypermedia design. Of particular interest to most researchers are the questions of what factors most affect user performance with digital documents and how best to exploit hypermedia for real-world tasks.

3. Fundamental differences between digital and analog media

Dillon (1994) outlined five outcome and three process variables that have been studied by researchers in hypermedia. The outcome variables are:

- Speed

- Accuracy

- Comprehension

- Fatigue

- Preference

In general, people have repeatedly been shown to read 20-30% slower from typical computer screens than paper (see e.g., Gould et al 1987).and this has given rise to a concern with image quality and research at the perceptual level of use. 'Accuracy' of use has proved more difficult to measure and many researchers have used highly constrained

tasks such as error location in proof-reading or searching for target information in an information space as indices of performance accuracy or effectiveness. The results are highly task-dependent but there are some suggestions that hypermedia is better suited to search and comparison tasks than complex learning tasks.

The effect of presentation medium on comprehension is particularly difficult to assess because of the lack of agreement about how comprehension can best be measured. However, in a detailed review of the learning outcomes of hypermedia and other instructional presentations, Dillon and Gabbard (1998) reported that the experimental findings show little support for the use of hypermedia over any other medium in educational settings.

There is also a popular belief that reading from screens leads to greater fatigue but the results are inconclusive. The perception of fatigue or eye strain from screen reading is obviously linked with the user's preference for screen or paper-based reading, where it seems that paper retains popularity with many users, although this is highly contingent on task.

The major process differences that have been experimentally studied include:

- Eye movements

- Manipulations

- Navigation

Comparison of eye-movements with paper and hypermedia documents shows that there is little difference although screen readers may make slightly more regressions (Gould et al 1987). Manipulation and navigation however are much more commonly assessed and the results indicate significant effects, with large hypermedia documents in particular producing navigation problems for users, leading to increased disorientation and poorer mental model formation of layout and narrative flow.

3. Explaining the differences

Hand in hand with the findings of significant process and outcome differences between the media has emerged a range of potential explanations for these differences. Following Dillon's (1994) review, these are grouped by human factors under physical, perceptual, cognitive, and social issues.

3.1 Physical sources of difference

There are wide ranging physical differences between paper and hypermedia that affect the manner in which readers use them, such as:

- Orientation

- Aspect ratio

- Handling and manipulation

- Display size

While myths abound on the theme of display size or orientation, research indicates that the major problems occur in designing appropriate manipulation facilities for the digital medium where there are few standards beyond the use of a mouse as a pointing and selection device. On balance, though, the empirical literature would seem to indicate that the primary causes of the reported performance differences between the media do not lie at the physical level of use.

3.2. Perceptual sources of difference

The user's visual processing of text and images is contingent on image quality which varies on computer screens as a function of the refresh rate and resolution. This has led to research into the relationship of image quality to user performance with digital documents. Some of the major areas of attention have been:

- flicker

- screen dynamics

- visual angle of view

- image polarity.

- anti-aliasing

The definitive work on perceptual variables in reading from computer screens was carried out by Gould et al (1987) who empirically demonstrated that under the right conditions differences between the digital documents and paper disappear. Their results suggested that the performance deficit in speed was the product of an interaction between a number of individually non-significant effects: display polarity (dark characters on a light, whitish background), improved display resolution, and anti-aliasing. This image quality hypothesis has been replicated by Muter and Maurutto (1991). It is fair to conclude that high image quality is a necessary (but insufficient) precondition of efficient and effective use of any hypermedia.

3.3. Cognitive sources of difference

While the identification of the role of image quality was an important breakthrough for our understanding of human response to digital information, the potential of hypermedia to represent information in novel and configurable forms is what truly interests designers and users. This potential has served to emphasize the importance of cognitive issues in design. To date, researchers have focused on the following type of variables:

- Visual memory for location and layout

- Schematic representations of concepts and relationships

- Navigation patterns and mental map formation

- Comprehension of various information structures

Issues relating to re-structuring of information, together with the nature and amount of linking involved with hypermedia, have become central questions of human factors researchers (see e.g. Nielsen, 1995). It is almost taken on faith by many that analog documents consist of a linear format which demands serial interactions while hypermedia allows non-linear formats which offer more flexible and "natural" methods of use. Such a distinction would appear dubious and there is little evidence to support either assumption.

Systematic research on cognitive issues shows that users can become overwhelmed with highly interlinked nodes of information that fail to cohere or conform to expectations of structure. This has given impetus to studies of the strategies people adopt in navigating through information spaces, the best representations of location and order to provide users at the interface, and the best combination and organization of images, text and sound to ensure learning. To date, few definitive answers have emerged and it remains a major design challenge to produce a hypermedia document that outperforms its paper equivalent.

4. Social sources of difference

In recent years interest in the social aspects of digital information creation and use has increased. As hypermedia becomes the universal interface style for so much of the information with which people interact, researchers have started to address the social and cultural variables that influence use and acceptance of digital documents. Issues that are seen as central at this level include:

- The sharing of meaningful representations

- Control of authorship

- Formation and application of document genres

- Collaborative hypermedia creation and use

It is clear that image quality is a necessary but insufficient to ensure usability and that any hypermedia system invariably exists in a socio-cognitive environment of use that transcends physical space. Creators and users of hypermedia might be physically and temporally separated, of different language communities and may create and shape personal hypermedia spaces that are unique. To date, most work on these issues has been discursive rather than empirical.

5. Designing usable hypermedia - users, tasks and information spaces

The World Wide Web is essentially a hypermedia environment and its rapid has increased the need for understanding how best to design hypermedia. The lesson from research is that while it is important to take account of the visual ergonomic issues, any hypermedia application will only be of benefit to users if it supports their navigation, location and sharing of information. Few computer-based innovations have proved so difficult to design so that users benefit significantly. Successful examples of hypermedia have only been developed through long-term iterative design processes involving frequent usability evaluations (see e.g., Landauer et al 1993).

While following an iterative user-centered design process is usually beneficial, it can be slow and costly. In one respect, hypermedia applications share many of the standard interface design problems of any other application in terms of icon design, color coding, error message and documentation design, screen layout etc. thus enabling designers to call on a large existing database of human factors research to guide parts of their design. What is specific to hypermedia, or at least what hypermedia places greater emphasis upon, is the flexibility afforded users to access any part of the information space they choose, the combinatorial form of the information types, and, with the WWW, the potential to traverse multiple sites which share nothing in common but a link.

Of necessity, any usable design must be grounded in the context of intended use which requires developers to analyze the users, their information tasks and the environment in which they will work. Large individual difference effects have been observed and hypermedia presentations often seem to hinder rather than help the people at whom they

are aimed (Dillon and Gabbard, 1998). Clearly users with experience with any information type have expectations of form and organization that might be leveraged in hypermedia designs.

While it was recognized early in the research literature that not all information was well served by being presented in hypermedia form, few definitive answers have been provided concerning just which types of information work best. Shneiderman (1989) stated that the best hypermedia were information types that were naturally fragmented and that users only want to access in parts. This might suggest some natural limits on the type of information that users wish to explore in hypermedia form, but as yet there appears to be no slowing of the push to digitize any and all types of information. Furthermore, such a perspective is limited to imagining hypermedia versions of existing forms of information- as hypermedia evolves we should anticipate the emergence of new document genres and types that have no analog equivalent.

Any analysis of information type cannot be divorced from task requirements users have for it. For example, the complete works of Shakespeare may not seem an ideal candidate for fragmentation and hyperlinking, yet a digital version would prove highly useful to a scholar searching for quotations or seeking parallels across plays or poems. Certainly, where location is supported by search facilities, hypermedia offers tremendous potential to users exploring large documents. However, once located, many users seem to prefer viewing a printed version of the target information. This suggests that thinking about hypermedia should move forward from comparisons with analog documents toward an appreciation of what contexts of use it best serves and how it might supplement and be supplemented by existing media to support any given users and tasks.

6. Recommendations

Hypermedia offers a powerful means of presenting large amounts of rapidly accessible information to a user that can be explored as needed. However, hypermedia can also overwhelm and disorient users if it is not well-designed. The concept of hypermedia is sufficiently wide-ranging to prevent simplistic design guidelines on link density or screen

size to be specified, although there is an ever-expanding list of design recommendations being pushed by web-designers. However, to maximize the advantages and minimize the potential problems the following general recommendations have emerged from the human factors research on hypermedia:

i. Provide high image quality screens to improve readability;

ii. Use colors sparingly; black text on white backgrounds is optimal for reading lengthy text;

iii. Support simple manipulation of screen contents with a mouse or equivalent input device; minimize repetitive motion such as scrolling through use of directly accessible navigation controls.

iv. Links should clearly signify destination and be retraceable; increasing link density can increase the cognitive load on users;

v. Structure the information to conform to user expectations, or provide structural cues such as maps or overviews to introduce new structures; Determine new structures by considering the tasks being performed;

vii. Use animation only to attract attention or convey a process;

viii. Minimize load time; Users strongly dislike waiting for screens to load;

ix. Add value by offering facilities to perform desirable or advantageous tasks that are impossible, difficult or time-consuming with analog media;

However, all the above recommendations are context-dependent and are less critical to the success of any hypermedia application than the central HCI recommendation of testing any design on real users.

Bibliography

BUSH, V. (1945) As we may think. *Atlantic Monthly*, 176,1, July, 101-108.

CONKLIN, J. (1987) Hypertext: an introduction and survey. *Computer*, September, 17-41.

DILLON, A. (1994) *Designing Usable Electronic Text: Ergonomic aspects of human information usage*. (Bristol PA: Taylor and Francis).

DILLON, A. and GABBARD, R. (1998) Hypermedia as an educational technology: s review of the quantitative research literature on learner comphrension, control and style. *Review of Educational Research*, 68, 3, 322-349.

GOULD, J. , ALFARO, L., FINN, R., HAUPT, B. and MINUTO, A. (1987) Reading from CRT displays can be as fast as reading from paper. *Human Factors*, 26(5) 497-517.

LANDAUER, T., EGAN, D. REMDE, J., LESK, M., LOCHBAUM, C. and KETCHUM, D. (1993) Enhancing the usability of text through computer delivery and formative evaluation: the SuperBook Project. In: C. McKnight, A. Dillon and J. Richardson, (eds.) *Hypertext: A Psychological Perspective*. (Chichester: Ellis Horwood), pp.71-136.

MUTER, P. and MAURUTTO, P. (1991) Reading and skimming from computer screens and books: the paperless office revisited? *Behaviour and Information Technology*, 10(4) 257-266.

NIELSEN, J. (1995) *Multimedia and Hypertext: the Internet and Beyond*. (Boston: AP Professional).

SHNEIDERMAN, B. (1989) Reflections on authoring, editing and managing hypertext. In E. Barratt., (Ed.) *The Scoiety of Text*, (Cambridge MA: MIT Press). pp.115-131.