THE STRUCTURE OF INFORMATION IN ONLINE AND PAPER TECHNICAL MANUALS

Linda J. Weldon
Carol Bergfeld Mills

Human-Computer Interaction Laboratory
Center for Automation Research
University of Maryland
College Park, Maryland

Larry Koved

IBM Yorktown Heights, and
Department of Computer Science
University of Maryland
College Park, Maryland

Ben Shneiderman

Department of Computer Science
University of Maryland
College Park, Maryland

ABSTRACT

An experiment was conducted to compare online computer manuals to paper manuals. For each type of manual there were two different database structures -- a linear (sequential) structure and a tree structure. The results showed that people using the paper manuals were faster at performing a switch setting task based on information in the manual than were people using the online manuals. No significant differences were found in speed of performance between the linear and tree structures. Nor were there any differences in the number of correct switch settings for the different types of manuals. The subjective evaluation data revealed that the online manuals were rated as better and judged to be more organized than the paper manuals.

INTRODUCTION

Technical manuals are becoming increasingly available on interactive computer systems. The implementation of online manuals generally is accomplished by making a direct translation of standard paper manuals into the computer. Previous research on readability has typically shown that paper is read faster and more accurately than computer screens. Although paper is presently superior in terms of readability and other dimensions (such as ease in adding personal modifications), computers have capabilities that would make them useful for storage and retrieval of technical information. For example, updates or corrections of manuals are more easily incorporated into online manuals than into paper manuals. In addition, computers have unique capabilities for rapid access of information.

The motivation for the present study was to investigate novel methods of structuring online information in an attempt to find ways to facilitate performance for online manuals. The present research compared two methods of structuring technical information databases, a linear structure and a tree structure. The structures were compared for both paper and online manuals.

A linear structure, as we defined it, has the properties presently found in many books and technical manuals. The chapters contain relevant high-level and associated detailed information within the bounds of the chapter. With a linear structure, all of the information about a given topic can be found by starting on the first page of the chapter and turning each page in order.

A tree structure has hierarchically organized information in that chapters contain the high-level information and only pointers to detailed information. The detailed information is accessed by using these reference pointers. With a tree structure, the high-level information about a given topic can be found in the chapter and more detailed information is found by referring to separate
sections of the manual.

It was thought that the linear structure might be more appropriate for paper manuals because of its familiarity, and that the tree structure might be more appropriate for online manuals because it allows rapid, direct access of information.

METHOD

Experimental Design

The experiment had a 2x2x12 design with mode of presentation (paper vs. online), structure of presentation (linear vs. tree), and trials (1-12) as factors. Both mode of presentation and structure of information were between-subject factors, while trials was a within-subject factor. The four experimental conditions were called online-tree, online-paper, paper-tree, and paper-linear.

The dependent measures were the time to solve the problems, the number of errors, the number of pages viewed, and subject evaluations.

Subjects

Forty students from the University of Maryland provided the data for this report. The subjects had little or no computer experience.

Materials

Manuals. A simulated electronic intercom maintenance manual was written for the experiment. Four versions were developed, one for each of the experimental conditions. Each version contained the same text and graphics; however, the organization in each version was different. A "page" in the manual is defined as a single page or screen of text with an accompanying page or screen of graphics.

The pages in the online-tree manual were organized hierarchically. Access to information in the manual was through pointers in the form of embedded menu choices. The embedded menus consisted of underlined phrases in the text. The reader could move the cursor to an underlined phrase in the text then select the phrase in order to display a detailed section on that topic.

The pages in the online-linear manual were organized in a sequential, or book, format. Access to the pages of the manual was through page-turning commands based on page number information.

The paper-linear manual was a paper version of the online-linear manual. The contents of the text and graphics had been printed on paper in the same format as they appeared on the computer screens.

The paper-tree manual was similar to the paper-linear version except that introductory pages of chapters were at the beginning of the manual and all detailed information sections referred to were at the back of the manual. The page numbers were the pointers to the detailed information.

Problem sets. Subjects used the manuals to determine the correct settings for two sets of eight dip switches that were soldered to a prototyping card. Twelve problems were constructed that required different combinations of on and off switch settings.

Questionnaire. A questionnaire was completed by the subjects after the experimental tasks. Nine questions concerned the subjective evaluation of the manual using a seven-point rating scale. The positive ends of the scales were: liked, useful, good, readable, understandable, easy to use, well-organized, easy to find, and did not lose place.

Procedure

The subjects were randomly assigned to one of the four experimental conditions.

Once the subjects had completed a practice problem with the type of manual they were to use in the experiment, they were given additional instructions describing the experimental task. They were told to set the sixteen switches based on the manual and the information that was provided.

The subjects in both computer and paper conditions were timed and their switch settings were recorded. After the subjects finished the twelve trials of setting the switches they completed the questionnaire.

Presentation methods. Subjects who were tested on the online manuals were using an IBM PC/XT microcomputer with two adjacent display screens. Text for the online manuals was displayed on a monochrome display with green phosphor, and graphics were displayed in a single color (yellow-gold) against a black background on the adjacent color display.
Subjects in the paper conditions used manuals with the printed pages placed in a binder. The graphics were displayed on the page facing the text page.

RESULTS

The mean total time in seconds per trial for each of the experimental conditions was: 135.1 for online-tree, 139.7 for online-linear, 115.2 for paper-tree, and 118.4 for paper linear. A 2x2x12 analysis of variance was performed on the total time per subject per trial, with mode, structure, and trials as factors. Prior to this analysis, the data were transformed using reciprocals. The results showed a significant effect of mode of presentation. The subjects in the paper conditions were faster (116.8 seconds) than the subjects in the online conditions (137.4 seconds).

There were no significant effects of linear vs. tree structure or interactions between mode and structure. There was a significant main effect of trials with subjects becoming faster on each successive trial. There was also a significant interaction between mode of presentation and trials. This interaction was due to the greater differences between the online and paper mode on early trials than on the late ones. The three-way interaction between structure, mode, and trials was also significant. The greatest differences between conditions occurred on trial 1 and the least difference on the later trials. Tukey's HSD test was performed on the four conditions for each trial. No significant differences were obtained. Hence, the significant interaction appears to be due to the different ordering of conditions across trials.

For each subject, the total number of errors in switch setting combinations was calculated. The error rate was relatively low; about 14% for the paper-tree condition and 6% for all other conditions. A 2x2 analysis of variance was performed on these data. There were no significant differences in the number of errors among the experimental conditions.

In the online conditions, the number of pages viewed was recorded. A 2x2x12 analysis of variance with structure and trials as factors indicated a significant difference between linear and tree structures. The overall mean number of total pages viewed was 12.3 in the linear condition and 18.3 in the tree condition. Subjects looked at more pages in the tree condition than in the linear condition. There was also a significant main effect of trials.

The subjective evaluation questions provided an indication of preference for the different types of manuals. Ratings were summed and a 2x2 analysis of variance with mode of presentation and structure of information as factors indicated a significant difference between online and paper modes. Subjects preferred the online mode over the paper mode (2.3 vs. 2.8 mean rating respectively, where 1 is positive and 7 is negative). There were no significant effects of structure or interactions between mode and structure in this analysis.

DISCUSSION

Technical manuals in two presentation modes (paper vs. online) using two information structures (linear vs. tree) were compared on a series of switch setting tasks. Subjects using paper technical manuals performed the tasks significantly faster than subjects using online technical manuals. There were no significant differences in performance time attributable to information structure or interactions between mode and structure. Subjects performed the tasks accurately, making few errors with any of the manual types.

There are indications that further tests of information structure might show a difference between linear and tree structures in online manual usage. Subjects using online-tree manuals viewed 48.8% more pages than the subjects with online-linear manuals. With the tree structure, a subject had to traverse through each node in a path through the manual. No shortcuts were available to allow the subject to skip a section or turn directly to a specific part of the manual. With the linear structure, as subjects worked the successive problems they began to skip directly to the pages of interest rather than looking at the relevant intermediate pages.

It had not been anticipated that the subjects would memorize as much of the manual structure as they evidently did. Memorization could account for the difference in number of pages seen in the online-linear and the online-tree conditions. Subjects with the online-tree manual may also have memorized the layout of the manual, but unlike the linear manual, no page-turning mechanism was available to allow them to use that knowledge to turn directly to the critical sections of the manual.
There were other indications that subjects may have been memorizing the contents and layout of the manuals. First, in all of the conditions and across all trials, the time to solve problems was steadily decreasing. Also, as measured in the online conditions, the subjects were viewing fewer pages during successive trials.

The technical manuals used in the present study were relatively short (55 pages maximum). With larger manuals, the contents may be less easy to find and the paths to the critical information may be less easy to memorize. Differences in information structure of manuals might become more important with larger databases of technical information.