Designing Menu Selection Systems

Ben Shneiderman
Department of Computer Science, University of Maryland, College Park, MD 20742

Menu selection systems reduce training and memorization, simplify entry of choices, and structure the user's tasks. However, the use of menu selection is no guarantee that novices or experts will be satisfied or able to carry out their work. This article focuses on the multiple design issues in creating successful menu selection systems. These include the primary issue of semantic organization and the host of secondary issues such as response time and display rates, shortcuts for frequent users, titles, phrasing of menu items, graphic layout, and selection mechanisms. Novel approaches such as pop-up menus and embedded menus are covered. Experimental results and design guidelines are presented.

1. Introduction

Menu selection systems are attractive because they can eliminate training and memorization of complex command sequences. When the menu items are written using familiar terminology, users can select an item easily and indicate their choice either with one or two keypresses or through the use of a pointing device. This simplified interaction style reduces the possibility of keying errors and structures the task to guide the novice and intermittent user. With careful design and high speed interaction, menu selection can become appealing to expert frequent users as well.

Interaction by menu selection is often contrasted with interaction by command language, but the distinctions are sometimes blurred. Typically menu selection requires a single keystroke, whereas commands may be lengthy. However, how would you classify a menu in which the user has to type a six or eight letter item? Typically, menu selection presents the choices on the display, whereas commands must be memorized. However, how would you classify a menu that offered 4 numbered choices and accepted 10 more generic choices that are not displayed? How would you classify a system that offers single letter prompts? What about graphical, two-dimensional menus where selection is made by pointing with a mouse or on a touchscreen? Finally, what category is voice synthesis/recognition menu interaction?

Rather than debate terminology, it is more useful to maintain an awareness of how much the system offers on the display at the moment the selection is made, the form and content of item selection, and what problem domain knowledge is necessary for users to succeed. Menu selection is especially effective when users have little training, are intermittent in using the system, are unfamiliar with the terminology, and need help in structuring their decision-making process.

However, if a designer employs menu selection, it does not guarantee that the system will be appealing and easy to use. Effective menu selection systems emerge only after careful consideration and testing of numerous design issues such as semantic organization, menu system structure, the number and sequence of menu items, titling, prompting format, graphic layout and design, phrasing of menu items, display rates, response time, shortcuts through the menus for knowledgeable frequent users, availability of help, and the selection mechanism (keyboard, pointing devices, touchscreen, voice, etc.).

2. Semantic Organization

The primary task for menu designers is to create a sensible, comprehensible, memorable, and convenient semantic organization. Some lessons can be learned by studying the semantic decomposition of a book into chapters, a program into modules, the animal kingdom into species, or a Sears catalog into sections. Hierarchical decompositions, natural and comprehensible to most people, are appealing because every item belongs to a single category. Unfortunately, in some applications an item may be difficult to classify as belonging to one category, and the temptation to duplicate entries or create a network increases. Despite some limitations, the elegance of tree structures should be appreciated.

Restaurant menus separate appetizers, soups, main dishes, desserts, and drinks to help customers organize

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their selections. Menu items should fit logically into categories and have readily understood meanings. Restaurateurs who list dishes with idiosyncratic names such as "Veal Monique," generic terms such as "house dressing," or unfamiliar jargon such as "Wor Shu Op" should expect that waiters will spend ample time explaining the alternatives or should anticipate that customers will be anxious because of their insecurity in ordering.

Similarly, for computer menu selection systems, the categories should be comprehensible and distinctive so that the users are confident in making their selections. Users should have a clear idea of what will happen when they make a choice. Computer menu selection systems are more difficult to design than restaurant menus because computer screens typically allow less information to be displayed than do printed menus. Screen space is a scarce resource. In addition, the number of choices and the complexity is greater in many computer applications, and the computer user may not have a helpful waiter to turn to for an explanation.

The importance of meaningful organization of menu items was demonstrated in a study with 48 novice users [1]. Simple menu trees with 3 levels and 16 target items were constructed in meaningfully organized and disorganized forms. Error rates were nearly halved, and user think time (time from menu presentation to user's selection of an item) was reduced for the meaningfully organized form. In a later menu search study, McDonald et al. [2] found that semantically meaningful categories, such as food, animals, minerals, and cities, led to shorter response times than did random or alphabetic organizations. This experiment tested 109 novice users who worked through 10 blocks of 26 trials. The authors conclude that "these results demonstrate the superiority of a categorical menu organization over a pure alphabetical organization, particularly when there is some uncertainty about the terms." With larger menu structures the effect is even more dramatic, as has been demonstrated by studies with extensive videotext databases [3,4].

These results and the syntactic/semantic model [5] suggest that the key to menu structure design is to first consider the semantic organization. The number of items on the screen becomes a secondary issue.

Menu selection applications range from trivial choices between two items to complex videotex systems with 300,000 screens. The simplest applications consist of a *single menu*, but even with this limitation there are many variations. The second group of applications includes a *linear sequence* of menu selections; the progression of menus is independent of the user's choice. Strict *tree structures* make up the third group, which is the most common situation. *Acyclic* (these are menus that are reachable by more than one path) and *cyclic* (there are meaningful paths that allow users to repeat menus) *networks* constitute the fourth group. These groupings describe the semantic organization; special traversal commands may enable users to jump around the branches of a tree, to go back to the previous menu, or to go to the beginning of a linear sequence.

A. *Single Menus*

In some situations, a single menu is sufficient to accomplish a task. Single menus may have two or more items, may require two or more screens, or may allow multiple selections. Single menus may pop up on the current work area or may be permanently available (in a separate window or on a data tablet) while the main display is changed. Different guidelines apply for each situation.

Binary Menus The simplest menu is a binary menu with yes/no or true/false choices such as is found in many home computer games:

DO YOU WANT INSTRUCTIONS (Y,N)?

or in a medical-history taking interview

YOU HAVE HAD SURGERY TO REMOVE YOUR APPENDIX
1 — TRUE
2 — FALSE
MAKE YOUR SELECTION NOW:

Even these simple examples can be improved. In the first case, a novice user might not understand the (Y,N) prompt—really an abbreviated form of the menu of choices. Secondly this common query leaves the user without a clear sense of what is going to happen next. Typing "Y" might produce many pages of instructions and the user might not know how to stop a lengthy output. Typing "N" is also anxiety producing because the user has no idea of what the program will do. Even in writing simple menus, clear and specific choices should be offered which give the user the sense of control:

Your choices are:
1 — Get 12 lines of brief instructions
2 — Get 89 lines of complete instructions
3 — Go on to playing the game
Type a number and press RETURN:

Since this version has three items, it is no longer a binary menu. It offers more specific items so the user knows what to expect, but it still has the problem that users must take instructions now or never. Another strategy might be:

At any time you may type
? — to get 12 lines of brief instructions
?? — to get 89 lines of complete instructions
Be sure to press RETURN after every command
Ready for game playing commands:

This example calls attention to the sometimes narrow distinction between commands and menu selection: the menu choices have become more command-like since the user must now recall the ? or ?? syntax.

The following examples illustrate additional issues in

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binary menus. Menu items can be identified by single letter mnemonics, as in this photo library retrieval system:

Photos are indexed by film type
B Black and white
C Color
Type the letter of your choice
and press RETURN:

or in a shop-by-computer service:

PLEASE SELECT THE DESIRED METHOD
OF BILLING:
MASTERCARD 1
VISA 2
KEY IN YOUR SELECTION AND PRESS ENTER:

The mnemonic letters in the photo menu are often preferred to the numbered choices in the shop-by-computer menu (see Section 7). The long line of periods can be a distraction, and the uppercase-only lettering may slow reading. The mnemonic letter approach requires additional caution in avoiding collision and increases the effort of translation to foreign languages, but their clarity and memorability are an advantage in many applications. These simple examples demonstrate alternative ways to identify menu items and convey instructions to the user. No optimal format for menus has emerged, but consistency across menus in a system is extremely important.

Multiple Item Menus Single menus may have more than two items. Examples include online quizzes:

Who invented the telephone?
1 Thomas Edison
2 Alexander Graham Bell
3 Lee De Forest
4 George Westinghouse
Type the number and press RETURN:

or the list of options in a document processing system:

EXAMINE, PRINT, DROP, OR HOLD?

The quiz example has distinctive, comprehensible items, but the document processing example shows an implied menu selection that could be confusing to novice users. There are no explicit instructions, and it is not apparent that single letter abbreviations are acceptable. Knowledgeable and frequent users may prefer this short form of a menu selection, usually called a prompt, for its speed and simplicity.

Extended Menus Sometimes the list of menu items may require more than one screen but allow only one meaningful item to be chosen. One resolution is to create a tree-structured menu, but sometimes the desire to keep the system to one conceptual menu is very appealing. The first portion of the menu is displayed with an additional menu item that leads to the next screen in the extended menu sequence. A typical application is in word processing systems, where common choices are displayed first but infrequent or advanced features are kept on the second screen:

SUPERDUPERWRITER MAIN MENU
PAGE 1

1 Edit a file
2 Copy a file
3 Create a file
4 Erase a file
5 Print a file
6 View the directory

P2 Go to PAGE 2

Type the number of your choice
and Press RETURN

SUPERDUPERWRITER MAIN MENU
PAGE 2

7 Alter line width
8 Change character set
9 Attempt recovery of damaged file
10 Reconstruct erased file
11 Set cursor blink rate
12 Set beep volume
13 Run diagnostics

P1 Go back to PAGE 1

Type the number of your choice
and Press RETURN

Sometimes the extended screen menu will go on for many screens of command items or data items. More elaborate scrolling capabilities may be needed.

Pop-up Menus The term "pop-up" or "pull down" menus refers to the process of forcing a menu to appear on the screen in response to a click with a pointing device such as a mouse. The Xerox Star, Apple Lisa, and Apple Macintosh (Figure 1) made these possibilities widely available. There is a great satisfaction on the part of most users in making the menu appear rapidly. Selection can be made by moving the pointing device over the menu items, which respond by highlighting (inverse video, a box surrounding the item, or color have been used).

The contents of the pop-up menu may depend on the position of the cursor when the pointing device is clicked. Since the pop-up menu covers a portion of the screen, there is a strong motivation to keep the menu text small. Hierarchical sequences are also used in pop-up menus.

Permanent Menus Since menus can be used for permanently available commands that can be applied to a displayed object. For example, the Bank Street Writer, a word processor designed for children, always shows a fragment of the text and this menu:

ERASE	MOVE	FIND	TRANSFER
UNERASE	MOVEBACK	REPLACE	MENU

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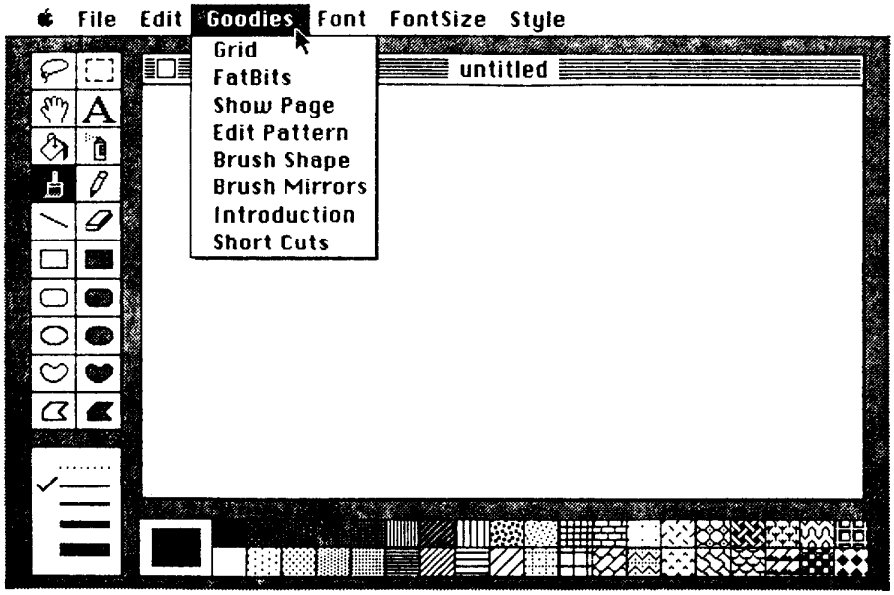

FIG. 1. Pulldown menu on the Apple Macintosh appears when the user clicks down on the mouse button.

Moving the left and right arrow keys causes items to be sequentially highlighted in reverse video. When the desired command is highlighted, pressing the RETURN key initiates the action.

Other applications of permanent menus include Apple Macpaint, computer-assisted design (CAD) systems, or other graphics systems that display an elaborate menu of commands to the side of the object being manipulated. Price [6] describes a CAD system with 120 choices in an on-screen menu. Lightpen touches or other cursor-action devices allow the user to make selections without using the keyboard.

Multiple Selection Menus A further variation on single menus is the capacity to make multiple selections from the choices offered. For example, this menu from a political interest survey allows multiple choices on one touch screen:

POLITICAL ISSUES

HIGH UNEMPLOYMENT
AID TO ELDERLY
NUCLEAR FREEZE
HIGH DEFENSE BUDGET
GOVERNMENT REGULATION
FOREIGN AID
PERSONAL TAXES
CIVIL DEFENSE
RIGHT TO ABORTION
CRIME CONTROL
MINORITY RIGHTS DONE

TOUCH UP TO THREE ISSUES THAT YOU
FEEL ARE THE MOST IMPORTANT,
AND THEN TOUCH DONE:

This situation is nicely handled with a multiple selection single menu; it would have been cumbersome to ask 11 binary choices when the user could not scan the full list of issues. The system might highlight already selected items with a check mark or bold face.

Summary Even the case of single menus provides a rich domain for designers and human factors researchers. Questions of wording, screen layout, and selection mechanism all emerge even in the simple case of choosing from one set of items. Still more challenging questions emerge from designing sequences and trees of menus.

B. Linear Sequence of Menus

Often a series of interdependent menus can be used to guide the user through a series of choices in which the user sees the same sequence of menus no matter what choices are made. A document printing package might have this linear sequence of menus:

Do you want the document printed at
1 — your terminal
2 — the computer center line printer
3 — the computer center laser printer
Type the number of your choice and press RETURN:

Do you want
1 — single spacing
2 — double spacing
Type the number of your choice and press RETURN:

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Do you want
1 — no page numbering
2 — page numbering on the top, right justified
3 — page numbering at the bottom, centered
Type the number of your choice and press RETURN:

Another example would be an online examination that had a sequence of multiple choice test items, each made up in the form of a menu.

Movement Through the Menus Linear sequences guide the user through a complex decision-making process by presenting one decision at a time. The document-printing example could be improved by offering the user a mechanism for going back to previous menus to review or change choices made earlier. A second improvement would be to display the results of previous choices, so users could see what decisions had been made. A third improvement might be to let the users know how many and which menus are yet to be seen.

The first improvement, allowing backward traversal, could be handled easily by changing the instructions to:

Type the number of your choice and press RETURN, or type "B" and press RETURN to go back to the previous menu:

The second improvement, showing the record of previous menus, could be handled by displaying the choices already made. The third improvement, showing upcoming choices, could be handled by displaying a descriptive term about the menus to follow, or simply an indication that this is the third of six menus. Unfortunately, as more improvements are made there is a greater possibility of creating cluttered displays. Judgments based on experience can resolve many decisions, but experimental tests with alternative formats and several classes of users may be useful to guide designers.

Summary Linear sequences of menus are a simple and effective means for guiding the user through a decision-making process. The user should be given a clear sense of progress or position within the sequence and the means for going backwards to earlier choices (and possibly to terminating or restarting the sequence).

Choosing the order of menus in a linear sequence is often straightforward, but care must be taken to match user expectations. One strategy is to place the easy decisions first to relieve users of some concerns, enabling them to concentrate on more difficult choices.

C. Tree-Structured Menus

When a collection of items grows and becomes difficult to maintain under intellectual control, people form categories of similar items, creating a tree structure [7,8]. Some collections can be easily partitioned into mutually exclusive groups with distinctive identifiers. Familiar examples include:

Male, female
Animal, vegetable, mineral
Spring, summer, autumn, winter
Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday
Less than 10, between 10 and 25, greater than 25
Percussion, string, woodwind, brass

Even these groupings may occasionally lead to confusion or disagreement. Classification and indexing is a complex task, and in many situations there is no perfect solution acceptable to everyone. The initial design can be improved as a function of feedback from users. Over time, as the structure is improved and as users gain familiarity with it, success rates will improve.

Despite their problems, tree-structured menu systems have the power to make large collections of data available to novice or intermittent users. If each menu has 8 items, then a menu tree with 4 levels has the capacity to lead an untrained user to the right frame out of a collection of 4096 frames.

If the groupings at each level are natural and comprehensible to the user, and if the user knows what he/she is looking for, then the menu traversal can be accomplished in a few seconds—more quickly than flipping through a book. On the other hand, if the groupings are unfamiliar and the user has only a vague notion of what he/she is looking for, it is possible to get lost in the tree menus for hours [9].

Depth Versus Breadth The depth (number of levels) of a menu tree depends, in part, on the breadth (number of items per level). If more items are put into the main menu, then the tree spreads out and has fewer levels. This is advantageous, but not if clarity is substantially compromised or if a slow display rate consumes the user's patience. Several authors have urged four to eight items per menu, but at the same time they urge no more than three to four levels. With large menu applications, one or both of these guidelines must be compromised.

D. P. Miller [10] studied user performance in retrieving items from 4 versions of a tree-structured menu system containing 64 target items. Menus had 2, 4, 8, or 64 items in each screen, with corresponding depths of 6, 3, 2, and 1. The 64 items were carefully chosen that "they form valid semantic hierarchies" in each of the 4 versions. Speed of performance was fastest with 4 or 8 items per menu, and the lowest error rate occurred with 8 items per menu. These results are useful, but there were two special conditions that may limit the applicability of this study: subjects became very familiar with the menus during the training and 128 trials, and the 64 items were chosen so that there were meaningful groupings in all 4 versions.

Kiger [11] grouped 64 items in 5 menu tree forms:

8-2: 8 items on each of 2 levels
4-3: 4 items on each of 3 levels
2-6: 2 items on each of 6 levels
4-1 + 16-1: A 4 item menu followed by a 16 item menu
16-1 + 4-1: A 16 item menu followed by a 4 item menu

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The deep narrow tree, 2-6, produced the slowest, least accurate, and least preferred version, whereas the 8-2 was among the best for speed, accuracy, and preference. The 22 subjects performed 16 searches on each of the 5 versions.

Dray et al. [12] compared a one-level menu having 23 one-word target items arranged on 6 lines with a two-level menu having 6 items in the main menu. Selection was by cursor control arrow keys and an ENTER key. Subjects had 138 trials in each condition in this counterbalanced within subjects design. Although neither version emerged as superior, there was a significant order effect that the authors interpreted as evidence that the one-level menu was easier to learn. Informal reports from subjects supported the conclusion that continuously seeing the full picture aided decision making.

When the menu tree contains the numbers 1–4096, time to locate a target number was found to increase with the breadth of the tree [13]. Search times were almost twice as long in a 12 level tree having 2 choices at each level (2-12) as opposed to a 3 level tree with 16 choices at each level (16-3). Although the 6 subjects made choices more rapidly in the shorter menus, the effort to work through the more numerous menus did slow them down substantially. Each subject did 12 trials with each of 4 widths.

While the semantic structure of the items cannot be ignored, these studies suggest that fewer levels aid decision making. Of course, display rates, response time, and screen clutter must be considered in addition to the semantic organization.

Semantic Grouping in Tree Structures Rules for semantic validity are hard to state, and there is always the danger that some users may not grasp the designer's organizational framework. Young and Hull [14] examined "cognitive mismatches" in the British Prestel viewdata system [15]. Problems included overlapping categories, extraneous items, conflicting classifications in the same menu, unfamiliar jargon, and generic terms. Based on this set of problems, the rules for forming menu trees might be:

1. *Create groups of logically similar items.* For example, a comprehensible menu would list countries at level one, states or provinces at level two, and cities at level three.
2. *Form groups that cover all possibilities.* For example, a menu with age ranges 0–9, 10–19, 20–29, and older than 30 makes it easy for the user to select an item.
3. *Make sure that items are non-overlapping.* Lower-level items should be naturally associated with a single higher-level item. Young and Hull offered an example of a poorly designed screen with "Places in Britain" and "Regions of England" as overlapping items on the same menu.
4. *Use familiar terminology, but ensure that items are distinctive from each other.* Choosing the right terminology is a difficult task; feedback from sample users will be helpful during design and testing.

Menu Maps As the depth of a menu tree grows, it becomes increasingly difficult for the user to maintain a sense of position in the tree, and a sense of disorientation, or of "getting lost," grows. To overcome this sense of disorientation, some menu systems come with a printed index of terms that is easier to scan than a series of screen displays. The British Prestel system offers a detailed cross referenced index that in 1982 was 34 pages long and contained thousands of entries. The CompuServe Information Service's November 1984 index contained almost 1000 subjects. It included a diagram, or map, of the first 3 levels of the tree structure, which contains 26 menus.

The relative merits of a map and an index were studied in a small menu structure with 18 animals as target items [16]. In this case, users who had the chance to study an index did somewhat better than a control group that had no special navigation aids. The group with an overall map did substantially better than both the index and control groups:

	Control	Index	Map
Number of subjects	10	8	8
Mean time per search	35.3	30.7	19.2
Mean choices per search	12.3	8.4	4.7

Menu learning for a three-level three-item (3-3) menu was studied with four forms of training [17]:

Online exploration. Subjects could explore the menus online.

Command sequences. Subjects studied the 27 paths typed on paper, e.g., Plans Division, Concepts, Systems Analyst

Frames. Subjects studied the 13 menu frames, such as
Plans Division
Concepts
Designs
Proposals

Menu map. Subjects studied a tree-structured layout of the 13 frames.

The 65 undergraduate subjects had a 12 minute training period, followed by a 10 minute work period. The results indicate a strong advantage for those who had the menu map:

	Online Exploration	Command Sequences Study	Frames Study	Menu Map Study	Significance
Targets found	8.2	4.7	6.5	8.5	N.S.
Average number of menus visited	10.6	20.4	19.6	9.4	$p < .10$
Recall of tree (max = 27)	10.1	8.4	9.8	16.7	$p < .05$
Satisfaction (best = 5)	3.6	3.1	2.8	4.8	$p < .01$

As the tree structure grows, users have greater difficulty in maintaining an overall understanding of the semantic

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organization. Viewing the structure one menu at a time is like seeing the world through a cardboard tube: it's hard to grasp the overall pattern and see relationships among categories. Offering a spatial map can help overcome this difficulty.

Semantic Versus Alphabetic Organization Since the creation of a universally acceptable semantic decomposition with several tree levels is a challenge, some designers have attempted an index strategy that provides a tree structure based on simple alphabetic organization of the target items.

There were 30 student volunteers tested in the use of a tree-structured database of 470 index pages and an alphabetic index of 453 terms [18]. A typical search of both forms proceeded as follows:

Tree Search for Baseball Scores

User sees:	1. News
	2. Sports
	3. Entertainment
User selects 2 and sees:	SPORTS
	1. Hockey
	2. Baseball
	3. ...
User selects 2 and sees:	BASEBALL
	1. Scores
	2. Standings
	3. ...
User selects 1 and sees:	BASEBALL SCORES

Alphabetic Search for Baseball Scores

User sees:	1. A-B-C
	2. D-E
	3. ...
User selects 1 and sees:	1. A
	2. B
	3. C
User selects 2 and sees:	DIRECTORY FOR B
	...
	Banks 22114
	Baseball.....221313
	Books.....2516
	...
User keys 221313 and sees:	BASEBALL
	1. Scores
	2. Standings
	3. ...
User selects 1 and sees:	BASEBALL SCORES

In this counterbalanced-within-subjects design, half the subjects began with one method and then tried the second method, while the other half of the subjects worked in the opposite order. Subjects performed 20 searches, and no significant differences were found in mean search time, number of keypresses, or number of menus accessed. Under both conditions, subjects "required about twice the minimum number of pages necessary to find the information" and "they made one or more errors on 40% of the questions." Users eventually succeeded in 98.7% of the questions, so that, although performance was far from optimal, successful searching was possible with both methods. Subjective evaluations did not favor one method over the other, but when one method required more pages for a specific question, the preference was for the shorter method.

Tombaugh and McEwen [18] conjectured that offering both methods may be the best resolution: subjects can choose the method that is most appealing for each question. If one method leads to difficulty, then the users can try the other.

Summary There is no perfect menu structure that matches every person's knowledge of the application domain. Designers must use good judgment for the initial implementation but then be receptive to suggested improvements and empirical data. Users will gradually gain familiarity, even with extremely complex tree structures, and will be increasingly successful in locating required items.

D. Acyclic and Cyclic Menu Networks

Although tree structures are very appealing, sometimes network structures are more appropriate. For example, it might make sense to provide access to banking information from both the financial and consumer parts of a tree structure. A second motivation for networks is that it may be desirable to permit paths between disparate sections of a tree rather than requiring users to begin a new search from the main menu. These and other conditions lead to network structures in the form of acyclic or even cyclic graphs. As users move from trees to acyclic networks to cyclic networks, the potential for getting lost increases.

With a tree structure, the user can form a mental model of the structure and the relationship among the menus. Developing this mental model may be more difficult with a network. With a tree structure, there is a single parent menu, so backward traversals toward the main menu are straightforward. In networks, a stack of visited menus must be kept to allow backward traversals.

In a thorough study of 17 subjects using menu networks of 50 frames, Mantei [19] concluded that "the structure of the user interface ... causes disorientation if this structure is not obvious to the user."

If networks are used, it may be helpful to preserve a notion of "level" or distance from the main menu. Users may feel more comfortable if they have a sense of how far they are from the main menu.

3. Item Presentation Sequence

Once the items in a menu have been decided on, the designer is still confronted with the problem of presentation

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Ex. 1156-007

sequence. If the items have a natural sequence such as days of the week, chapters in a book, or sizes of eggs, then the decision is trivial. Typical bases for sequencing items include

1. *Time*: chronological ordering.
2. *Numeric ordering*: ascending or descending ordering.
3. *Physical properties*: increasing or decreasing length, area, volume, temperature, weight, velocity, etc.

Many cases have no natural ordering, and the designer must choose from possibilities such as

4. *Alphabetic sequence of terms.*
5. *Grouping of related items*, with blank lines or other demarcation between groups.
6. *Most frequently used items first.*
7. *Most important items first.* Importance may be difficult to decide and may vary among users.

Card [20] experimented with a single 18-item vertical permanent menu of text editing commands such as "insert," "italic," and "center." He presented subjects with a command, and they had to locate the command in the list, move a mouse-controlled cursor, and select the command by pressing a button on the mouse. The menu items were sequenced one of three ways: alphabetically, in functional groups, and randomly. Each of 4 subjects made 86 trials with each sequencing strategy. The mean times were:

Alphabetic	0.81 seconds
Functional	1.28 seconds
Random	3.23 seconds

Since subjects were given the target item, they did best when merely scanning to match the menu items in an alphabetic sequence. The performance with the functional groupings was remarkably good, indicating that subjects began to remember the groupings and could go directly to a group. In menu applications where the users must make a decision about the most suitable menu item, the functional arrangement might become more appealing. Memory for the functionally grouped items would be likely to surpass memory for the alphabetic or random sequences. The poor performance with the random sequence confirms the importance of considering alternative item presentation sequences.

With a 64-item menu the time for locating a target word was found to increase from just over 2 seconds for an alphabetic menu to above 6 seconds for a random menu [2]. When the target word was replaced with a single line definition, the 109 subjects could no longer scan for a simple match and had to consider each menu item carefully. The advantage of alphabetic ordering nearly vanished. User reaction time went up to about 7 seconds for the alphabetic and about 8 seconds for the random organization. Somberg and Picardi [21] studied user reaction times in finding which category a target word belonged to in a 5 item menu. Their 3 experiments revealed a significant and nearly linear relationship between the user's reaction time and the serial position of the correct category in the menu. Furthermore, there was a significant increase in reaction time if the target word was unfamiliar rather than familiar.

4. Response Time and Display Rate

A critical variable that may determine the attractiveness of menu selection is the speed at which users can move through the menus. The two components of speed are system response time, the time it takes for the system to begin displaying information in response to a user selection, and display rate, the rate in characters per second at which the menus are displayed.

Deep menu trees or complex traversals become annoying to the user if system response time is slow, resulting in long and multiple delays. With slow display rates lengthy menus become annoying because of the volume of text that must be displayed. In positive terms, if the response time is long, then create menus with more items on each menu to reduce the number of menus necessary. If the display rate is slow, create menus with fewer items to reduce the display time. If the response time is long and the display rate is low, menu selection is very unappealing and command language strategies, despite the greater memory demands on the users, become more attractive.

With short response times and rapid display rates, menu selection becomes a lively medium that can be attractive even for frequent and knowledgeable users.

In a study carried out under this author's direction by Carl Bean and Joel Gallun, 12 psychology undergraduates were given two 5-minute menu selection tasks. Half the subjects went from 300 baud (approximately 30 characters per second) to 1200 baud (approximately 120 characters per second) display terminals, while the other half were tested in the reverse order. The average number of correctly completed searches went from 2.17 to 3.33 as the display rate was increased, a statistically significant difference ($p < .01$). Subjective preference scores and anecdotal reports strongly favored the faster display rate.

In 5 studies with 165 adult users of a videotex system, response time delay pairs (0 versus 10 seconds, 10 versus 15 seconds, and 3 versus 7 seconds) did not yield a statistically significant difference in the preference or performance measures tested [22]. The authors interpretation was that "inexperienced videotex users are relatively immune to a wide range of constant values of system delay." In many situations, novice users appreciate slow response times, but the large variations in individual performance may have obscured the usual preference for faster response times. Murray and Abrahamson [22] did, however, find a significant effect that indicated that large variations in response time led to slower rates of responding.

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5. Moving Through Menus Quickly

Even with short response times and high display rates, frequent menu users may become annoyed with having to make several menu selections to complete a task [23]. There may be some advantage to reducing the number of menus by increasing the number of items per menu, where possible, but this may not be enough. As response times lengthen and display rates decrease, the need for shortcuts through the menus increases.

Instead of creating a command language to accomplish the task with positional or keyword parameters, the menu approach can be refined to accommodate expert and frequent users. There have been three approaches used: allow typeahead for known menu choices, assign names to menus to allow direct access, and create menu macros that assign names to frequently used menu sequences.

A. Menus with Typeahead—The BLT Approach

A natural way to permit frequent menu users to speed through the menus is to allow "typeahead": the user does not have to wait to see the menus before choosing the items but can type a string of letters or numbers when presented with the main menu. For example, in the document-printing package in Section 2.2, the user could type 121 to get printing at the terminal, double spacing, and no page numbering. The IBM Interactive System Productivity Facility (ISPF) has numbered choices and allows typeahead with a decimal point between choices (e.g., 1.2.1). Full duplex systems such as Control Data Corporation's PLATO Computer-Based Education System naturally permit typeahead because pressing of a special RETURN or NEXT key is not required—single keystrokes cause an interrupt at the central computer.

If the menu items are identified with single letters, then the concatenation of menu selections in the typeahead scheme generates a command name that acquires mnemonic value. To users of a photo library search system that offered menus with typeahead, a color slide portrait quickly became known as a CSP, and a black & white print of a landscape became known as a BPL. These mnemonics come to be remembered and chunked as a single concept. This strategy quickly became known as the "BLT approach" after the abbreviation for a bacon, lettuce, and tomato sandwich.

The attraction of the BLT approach is that users can gracefully move from being a novice menu user to being a knowledgeable command user. There are no new commands to learn, and as soon as users become familiar with one branch of the tree, they can apply that knowledge to speed up their work. Learning can be incremental: users can apply one, two, or three letter typeahead and then explore the less familiar menus. If users forget part of the tree, they simply revert to menu usage.

The BLT approach requires a more elaborate parser for the user input, and handling nonexistent menu choices is a bit more problematic. It is also necessary to ensure that there is a distinct first letter for items within each menu, but not across menus. Still, the typeahead or BLT approach is attractive because it is powerful, simple, and allows graceful evolution from novice to expert.

B. Menu Names for Direct Access

A second approach to support frequent users is to use numbered menu items and to assign names to each menu frame. Users can follow the menus or, if they know the name of their destination, they can type it in and go there directly. The CompuServe information utility has a 3 letter identifier for major topics, followed by a dash and a page number. Rather than working their way through 3 levels of menus at 30 characters per second, they know that they can go directly to TWP-1, the start of the subtree containing today's edition of *The Washington Post.*

This strategy is useful if there are a small number of destinations that each user needs to remember. If users need to access many different portions of the menu tree, then it becomes difficult to keep track of the destination names. A list of the current destination names is necessary so that designers are sure to create unique names for new entries.

C. Menu Macros

A third approach to serving frequent menu users is to allow regularly used paths to be recorded by users as menu macros. In other words, users can define their own commands. A user can invoke the macro facility, traverse the menu structure, and then assign a name. When the name is invoked, the traversal is executed automatically. This mechanism allows individual tailoring of the system and can provide a simplified access mechanism for users with limited needs.

6. Menu Screen Design

Very little experimental research has been done on menu system screen design. This section contains many subjective judgments that are in need of empirical validation.

A. Titles

Choosing the title for a book is a delicate matter for an author, editor, or publisher: a more descriptive or memorable title can make a big difference in reader responses. Similarly, choosing titles for menus is a complex matter that deserves serious thought.

For single menus, a simple descriptive title that identifies the situation is all that is necessary. With a linear sequence of menus, the titles should accurately represent the stages in the linear sequence. For the menus in the document-printing package referred to in Section 2.2, the titles might be "Printing location," "Spacing control," and "Page numbering placement." Consistent grammatical style can reduce confusion. If the third menu were ti-

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tled "How do you want page numbering to be done?" or "Select page numbering placement options," the excess verbiage would be a distraction. Brief noun phrases are often sufficient.

For tree-structured menus, choosing titles is more difficult. Titles such as "Main menu" or topic descriptions such as "Bank transactions" for the root of the tree clearly indicate that the user is at the beginning of a session. One potentially helpful rule is to use the exact words in the high-level menu items as the titles for the next lower-level menu. It is reassuring to users to see an item such as "Business and financial services" and, after selecting it, to see that the screen is also entitled "Business and Financial Services." It might be unsettling to get a screen titled "Managing your money" even though the intent is similar. Imagine looking in the table of contents of a book and seeing a chapter title such as "The American Revolution" but, upon turning to the indicated page, finding "Our Early History"; you might worry about whether you had made a mistake, and your confidence might be undermined.

Using menu items as titles may encourage menu authors to choose items more carefully because they consider the descriptiveness in two contexts.

A further concern is consistency in placement of titles and other features in a menu screen. Teitelbaum and Granda [24] demonstrated that user think time nearly doubled when the position of information, such as titles or prompts, was varied on menu screens.

In networks of menus, titles become even more important as a guidepost because the potential for confusion is greater. If menu items are made to match the title, then several menus in a network may have the same items. It is satisfying to find the item "Electronic mail" in several menus, but unsettling to find menus with variant terms such as "Electronic mail," "Sending a note to another user," and "Communicating with your colleagues."

B. Phrasing of Menu Items

Just because a system has menu choices written with English words, phrases, or sentences does not guarantee comprehensibility. Individual words may not be familiar to some users, and often two menu items may appear to satisfy the user's needs. This is an enduring problem with no perfect solution. Designers can gather feedback from colleagues, users, pilot studies, acceptance tests, and user performance monitoring. The following guidelines may seem obvious, but they need to be stated since they are so often violated:

1. *Use familiar and consistent terminology.* Carefully select terminology that is familiar to the designated user community and keep a list of these terms to facilitate consistent use.
2. *Ensure that items are distinct from one another.* Each item should be clearly distinguished from other items. For example, "Slow tours of the countryside," "Journeys with visits to parks," and "Leisurely voyages" are less distinctive than "Bike tours," "Train tours to national parks," and "Cruise ship tours."
3. *Use consistent and concise phrasing.* The collection of items should be reviewed to ensure consistency and conciseness. Users are likely to feel more comfortable and be more successful with "Animal," "Vegetable," and "Mineral" than with "Information about animals," "Vegetable choices you can make," and "Viewing mineral categories."
4. *Position the keyword at the left.* Try to write menu items so that the first word aids the user in recognizing and discriminating among items. Users scan menu items from left to right, and if the first word indicates that this item is not relevant, they can begin scanning the next item.

C. Graphic Layout and Design

The constraints of screen width and length, display rate, character set, and highlighting techniques strongly influence the graphic layout of menus. Presenting 50 states as menu items was natural for the Domestic Information Display System built by NASA on a large screen with rapid display rate. On the other hand, the CompuServe Information Service, which must accommodate microcomputer users with 40 column displays over 30 character per second phone lines, uses this main menu page:

```
CompuServe                    TOP

 1 Instructions/User Information
 2 Find a Topic
 3 Communications/Bulletin Bds.
 4 News/Weather/Sports
 5 Travel
 6 The Electronic MALL/Shopping
 7 Money Matters/Markets
 8 Entertainment/Games
 9 Home/Health/Family
10 Reference/Education
11 Computers/Technology
12 Business/Other Interests

ENTER CHOICE NUMBER !
```

As users move down the tree they find the page numbers always displayed at the upper right, a title, numbered choices, and instructions. This consistent pattern puts users at ease and helps them sort out the contents. Menu designers should establish guidelines for consistency of at least these menu components:

1. *Titles.* Many designers prefer centered titles, but left justification is an acceptable approach.
2. *Item placement.* Typically items are left justified with the item number or letter preceding the item description. Blank lines may be used to separate meaningful groups of items. If multiple columns are used, a consistent pattern of numbering or lettering should be used, e.g., down the columns.
3. *Instructions.* The instructions should be identical in each menu and they should be placed in the

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same position. This includes instructions about traversals, help, or function key usage.

4. *Error messages.* If the users make an unacceptable choice, the message should appear in a consistent position.
5. *Status reports.* Some systems indicate which portion of the menu structure is currently being searched, which page of the structure is currently being viewed, or which choices must be made to complete a task. This information should appear in a consistent position.

Consistent formats aid in the location of necessary information, focus attention on relevant material, and reduce anxiety by offering predictability.

More on Titles Since disorientation is a potential problem, techniques to indicate position in the menu structure can be useful. In books different typefaces and typesizes indicate chapter, section, and subsection organization. Similarly in menu trees, as the user goes down the tree structure, the titles can be designed to indicate the level or distance from the main menu. If different typefaces, character sizes, or highlighting techniques are available, they can be used beneficially. But even simple techniques with upper case only can be effective; for example,

★★★★★★★★★★★★★★★★★★★★★★★★★★★★★
★ MAIN MENU ★
★★★★★★★★★★★★★★★★★★★★★★★★★★★★★

followed by

★ ★ ★ HOME SERVICES ★ ★ ★

followed by

- - NEWSPAPERS - -

followed by

New York Times

gives a clear indication of progress down the tree. When the user traverses back up the tree or to an adjoining menu at the same level, there is a feeling of confidence in the action.

With linear sequences of menus, the users can be given a simple visual presentation of position in the sequence by the use of a "position marker." In a computer-assisted instruction sequence with 12 menu frames, a position marker might be placed unobtrusively on the screen. In the first frame the position marker was +————————————, in the second frame it was —+————————————, and in the last frame it was ————————————+. The users can gauge their progress and see how much remains to be done. The position marker served to separate the items from the instructions in a natural way, and the position was indicated in a nonobtrusive manner.

With rapid high resolution displays, more elegant visual representations are possible. With enough screen space it is possible to show a large portion of the menu map, allowing the users to point at a menu anywhere in the tree. Graphic designers or layout artists may be useful consultants in design projects.

7. Selection Mechanisms

At first glance, choosing the menu selection mechanism appears to be one of those minor design decisions that can be made quickly, so that the design team can get on to more important matters. On the other hand, the selection mechanism is the central aspect of the menu system for most users.

This issue might be simplified to be: Should the designer use numbers or letters for indicating menu items?

Numbered Items The argument in favor of numbers is that there is a clear sequencing of items, and even nontypists can find the numbers on the keyboard. In some systems numeric keypads are the only input device (such as a telephone). Sequential numbering is satisfying because the user can quickly see how many items there are, and visual scanning is aided by the natural numeric ordering. As the user scans down the items, he/she can use the numbers as a guide to make sure that each choice is reviewed. When menu items have a natural numeric sequence, such as the 12 months of the year, the chapters of a book, the days of the week, etc., numbered choices are very appealing.

The disadvantages of numbers is that, when there are more than 10 items, 2 keypresses are required to make a selection. Another problem with numbers only is that if there are standard menu items such as HELP or BACK TO MAIN MENU, then these items may have a different number on each screen. If there is no natural numbering of menu items, then the numbering may be misleading, somehow indicating preference for number 1. Attaching numbers to a group of colors or to bank loan plans may mislead the user into believing that there is some hidden sequencing or preference.

Lettered Items If letters are used for menu items, then the choice is between A, B, C, D, E, F, etc., lettering (sequential) and meaningful letter choices (mnemonic). Sequential lettering is similar to numbering, out there are 26 choices available before 2 keypresses are required. There is some evidence that there is less likelihood of a keying error with letters than with numbers because the letters are more spread out on the keyboard. It may be a bit more tricky for someone unfamiliar with a typewriter keyboard to locate the proper letter, but this does not appear to be a serious hindrance. Mnemonic lettering for menu items is appealing because the congruence between the description of the item and the keypress can build user confidence in the task. For example, it makes sense to see that T is for TRANSFER and W is for WITHDRAWAL.

Of course, there are mixed strategies. Some systems, such as CompuServe, use numbers for the primary menu items and letters for generic functions such as M to get to the previous MENU and H to get to helpful information.

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This approach solves some problems and helps clarify the grouping of menu items. Other systems, such as PLATO, alternate between numbered and lettered menus to prevent inadvertent menu skipping caused by double keypresses, a problem with early PLATO keyboards.

Perlman [25] found user think times to be shortest with mnemonic letter items and longest with sequential (and therefore non-mnemonic) letter items. Numbered items produced a middle level of user think time.

A. Typeahead Selections

The design decision cannot be made without looking at the larger issue of tasks that require several menu selections. If a sequence of menus is to be viewed, the mnemonic lettering approach gains substantially because the user can remember sequences such as TCS, for Transfer from Checking to Saving, more easily than 253. If the user can type these selection letters before seeing the full menu, then the mnemonic lettering approach becomes a command language for the frequent user. This typeahead approach (Section 5.1) is very powerful since it makes the same system appealing to novices and frequent users. Furthermore, it facilitates the graceful evolution from novice to expert: users type ahead only as much as they can remember and then examine the next menu.

B. System Evolution

Another advantage of mnemonic lettering is that as items are added to menus there is no need to renumber the other choices. Mnemonic lettering does have the problem of collisions, that is, more than one choice with the same first letter. This is a serious concern, but often an acceptable alternative term can be found. If not, then using more than one letter of the term may be necessary.

C. Data Entry

If numeric data entry is to be made on some menu/data entry screens, then the lettered item approach will be advantageous since the typeahead command string will be more comprehensible. For example, depositing $40.00 into savings account 38847 might be entered as D40.00S38847, which may be more meaningful than 340.00638847. On the other hand if the data entry is for alphabetic strings, then the numbered approach might yield a more comprehensible command string. The alternation of letters and numbers helps break a string into more meaningful chunks.

D. Alternative Strategies

Instead of typing a choice, users can move a cursor to the intended item. The cursor could be moved by arrow keys, joysticks, tab key, or by a touch screen. This approach is appealing to novice users for single screen selections, even though there may be more keystrokes and the RETURN key must be pressed. There is a great sense of satisfaction in being able to move the cursor around the screen; the menu item is highlighted clearly on the screen and in the user's mind, and screen space is conserved since item numbers are not needed. In fact, highlighting, underscoring, boxes, pointers, color, or inverse video can be used to visually indicate the item that has been selected. Of course, this approach does not lend itself to typeahead schemes.

In an unpublished memo, Dunsmore reported the results of a 1981 study conducted at Purdue University in which 36 high school students used 3 forms of menu selection. Item-RETURN called for typing the number of the item, followed by the RETURN key. Immediate response eliminated the need to type RETURN. Highlight-RETURN called for typing the item, which was then highlighted by inverse video until the RETURN key was pressed. Each subject worked for 3 minutes with each form. The results were:

	Mean Tasks Completed	Total Errors	Preferred Form
Item-RETURN	14.8	4	0 subjects
Immediate response	15.5	7	7 subjects
Highlight-RETURN	15.3	3	29 subjects

Subjects worked slightly faster with the immediate response form, but the error rate was highest. The subjective preference strongly favored the highlighting, which looks very impressive to novice users.

8. Embedded Menus

All the menus discussed thus far might be characterized as explicit menus: there is an orderly enumeration of the menu items with little extraneous information. However, there are a number of situations where the menu items might be embedded in text or graphics and yet still be selectable.

In designing a textual database about people, events, and places for a museum application, it seemed natural to allow users to retrieve detailed information by selecting a name in context. Selectable names were highlighted, and the user could move an inverse video bar among highlighted names by pressing the four arrow keys (Figure 2). Selection was made by pressing RETURN, and the user obtained a new article plus the option of returning to the previous article. The names, places, phrases, or foreign language words were menu items embedded in meaningful text that informed the user and helped clarify the meaning of the items. Subsequent implementation used mouse selection or touchscreens, leading to the generic term *touchtext* for this application of embedded menus. Touchtext was also used in an implementation of online maintenance manuals that provided diagnostic information in textual form on one monitor and graphics assistance on a second monitor [26].

Embedded menus have emerged in other applications. Air traffic control systems allow selection of airplanes in

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Ex. 1156-012

INTRODUCTION: STAMP UNION PAGE 1 of 2

The Adele H. Stamp Union, formerly known as the Student Union, is the cultural and social center for the University. The Union provides a variety of services to the faculty, staff, and students. A plethora of **restaurants** are available providing a wide choice of atmosphere and a variety of menus. The Union is also center for **entertainment**. Several **shops** and many **special services** are available, too. **Union programs** include concerts, exhibitions, and craft classes. The Union is open all week from 7 A.M. to 1 A.M. Monday through Friday, and until 2 A.M. on weekends.

[Select option then press RETURN]

NEXT PAGE END

FIG. 2. Display of Stamp Union database article showing embedded menu. References shown here in boldface appear highlighted on screen. Reverse video selector box initially covers NEXT PAGE command. User moves selector box over highlighted reference or command, then selects by pressing the RETURN key. Since this is the first page of the first article in the database, the commands BACK PAGE and RETURN TO [previous article] are not shown.

the spatial layout of flight paths to provide more detailed information for controllers. Geographic display systems allow users to select cities or zoom in on specific regions to obtain more information [27]. In these applications the items are icons, text, or regions in a two-dimensional layout.

Language-directed editors permit users to select programming language constructs for expansion during the program composition process [28]. In a program browser at the University of Maryland, Phil Shafer offered programmers the capability of moving the cursor onto a variable name or procedure invocation, pressing a function key, and receiving the data declaration or procedure definition in a separate window. The variable and procedure names were menu items embedded in the context of a Pascal program.

Many spelling checkers make use of the embedded menu concept by highlighting the possibly misspelled words in the context of their use. The author of the text can move a cursor to a highlighted word and request possible words or type in the correctly spelled word.

Embedded menus permit items to be viewed in context and they eliminate the need for a distracting and screen-wasting enumeration of the items. Contextual display helps keep the users focused on their tasks and on the objects of interest. Items rewritten in a list may require longer descriptions of the items and may increase the difficulty in making selections because of the confusion when cross referencing between the menu and the context.

9. Practitioner's Summary

Begin by understanding the semantic structure of your application within the vast range of menu selection situations. Concentrate on organizing the sequence of menus to match the user's tasks, ensure that each menu is a meaningful semantic unit, and create items that are distinctive and comprehensible. If some users make frequent use of the system, then typeahead, shortcut, or macro strategies should be allowed. Permit simple traversals to the previously displayed menu and to the main menu. Finally, be sure to conduct human factors tests and involve human factors specialists in the design process [29]. When the system is implemented, collect usage data, error statistics, and subjective reactions to guide refinement.

Whenever possible, use a menu builder/driver system to produce and display the menus. Commercial menu creation systems are available and should be used to reduce implementation time, ensure consistent layout and instructions, and simplify maintenance.

10. Researcher's Agenda

Experimental research could help refine the design guidelines concerning semantic organization and sequencing in single and linear sequences of menus. How can differing communities of users be satisfied with a common semantic organization when their information needs are very different? Should users be allowed to tailor the structure of the menus, or is the advantage greater in compelling everyone to use the same structure and terminology? Should a tree structure be preserved even if some redundancy is introduced? How can networks be made safe?

Research opportunities abound. Depth versus breadth tradeoffs under differing conditions need to be studied to provide guidance for designers. Layout strategies, wording of instructions, phrasing of menu items, use of color, response time, and display rate are all excellent candidates for experimentation. Exciting possibilities are becoming available with larger screens or multiple displays and novel selection devices.

Implementers would benefit from the development of software tools to support menu system creation, management, usage statistics gathering, and evolutionary refinement. Portability of "menu-ware" could be enhanced to facilitate transfer across systems.

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