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Using Cognitive Networks
to Create Menus

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TABLE OF CONTENTS

PAGE

LIST OF TABLES AND FIGURES iii

INTRODUCTION 1

METHOD 2

PHASE I DESIGNING MENUS.......................... 2

PHASE II EVALUATING MENUS 3

RESULTS AND DISCUSSION 4

SUMMARY 7

REFERENCES 7

USING COGNITIVE NETWORKS TO CREATE MENUS

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ABSTRACT

Designing software ~~which~~ is easy to learn and use is the primary goal of software Human Factors. This paper presents a method for achieving this goal by designing menus based on the cognitive representations of users. In this study, cognitive networks for novice and expert users of an operating system were generated using similarity ratings, a sorting task and the Pathfinder algorithm. Three menus, two based on the cognitive networks and one alphabetically organized, were developed and experimentally evaluated. Participants in the cognitive network menu conditions learned operating system commands at a significantly faster rate than those using the alphabetical menu.

LIST OF TABLES AND FIGURES

TABLE PAGE

1. Number of Participants in groups Reaching Each Level of Learning 5

2. Mean Number of Blocks And Comparisons for Menu Conditions Collapsed Over Percent Learned 5

3. Mean Number of Blocks and Comparisons For Menu Conditions At 90% Learning 7

FIGURE

1. Blocks to Criterion for Participants Learning 90% of the Command Names 6

INTRODUCTION

Menus are designed with two goals in mind. The first goal is to facilitate search so that users quickly learn the location of options on a menu. The second goal concerns how easily users learn the system and make the transition from one level of expertise to another. One way of looking at this is the rate at which a user makes the transition from a menu interface to a command dialogue.

One design variable that influences the achievement of these goals is the specific arrangement of items in menus. Several methods for organizing menu options have been traditionally used. These include: arrangements based on functional groupings, frequency of use, alphabetical order, importance of use, and arrangements based on how users store information in memory. This last approach is better known as cognitive modelling and is the focus of this paper.

Research has demonstrated the use of cognitive representations as a method for organizing information, and in some cases studies have reported a positive influence on search time. For example, McDonald, Stone and Liebelt (1983) used Multidimensional Scaling solutions (MDS) and Hierarchical Cluster analysis to derive menu organizations for a list of well known terms. Response time for locating targets was evaluated by presenting participants with either the exact target or a target definition. The menu organizations generated from MDS solutions were found to be superior to random and alphabetical arrangements when definitions were provided as stimuli.

In 1985, Tullis reported using a sorting task and hierarchical cluster analysis to determine users' perceptions of relationships among operating system commands. Based on this procedure a menu organization for 700 unique functions was derived. Performance on these menus, however, was not reported.

In 1985 Roske-Hofstrand and Paap also used similarity ratings and the Pathfinder algorithm, developed by Schvaneveldt, Durso and Dearholt (1985) to derive cognitive networks on which a menu driven interface for a flight management system was designed. In this study, three menu prototypes were developed based on the cognitive networks of pilots and compared to a fourth prototype generated by a design team. The network prototypes differed in the amount of redundancy found in the menu. Redundancy refers to the number of times a specific option appeared on more than one panel. For tasks involving learning the location of targets, the cognitive network menus were shown to be superior to the design team menu.

The present research is a continuation of the investigations concerning the development of menus based on cognitive networks. The purpose of this study was to: 1) develop a menu interface for an operating system that would facilitate the transition from a novice to experienced user and 2) compare this method of learning the operating system to the existing method of a command dialogue.

METHOD

PHASE 1. DESIGNING MENUS

Phase I of the study consisted of designing a menu based on the cognitive representations provided by users.

Research (McKeithen, Reitman, Rueter & Hirtle 1981, Chase & Simon, 1973, Engle & Bukstel, 1978) has shown that the organization of information in memory is a function of experience with the knowledge domain. Therefore, one would expect to obtain different representations with different levels of expertise. To determine the most effective representation for designing the menus, cognitive networks were generated for both novice and expert users of the operating system.

Participants

Nineteen participants took part in Phase 1 of the study: 9 novice and 10 experts at using the operating system commands. A "novice" could freely recall no more than 5 commands, while "experts" could recall at least 15 of the 43 operating system commands.

Materials & Procedures

A description for each of the 43 commands was written on a 3 X 5 card. Subjects were asked to sort the commands into piles based on their similarity and then provide a similarity rating for each pair of piles. The rating scale was from 1, highly similar, to 9, highly dissimilar.

A cumulative data matrix was derived based on the sorting task and similarity ratings. The procedure for constructing this matrix was as follows. Every possible pair of definitions within a pile received a rating of 0. Pairs of definitions in different piles received the rating assigned by subjects to the pairs of piles.

The cumulative data matrix was then used as input to the Pathfinder algorithm. Pathfinder generates a family of link weighted networks from any set of distance data, which in this case were similarity ratings. The derived network consists of a set of nodes and links that directly connect pairs of nodes that are highly related. A node in this case was an operating system command. This step resulted in two networks, one for the novice and one for the expert operating system user. The networks were then examined and the commands were grouped using a Grouping algorithm (Rotella, Happ, Snyder, Dyck 1985). This Grouping algorithm breaks the network into logical groups based on the weights of the links. As a result, commands rated as highly similar are grouped together.

PHASE TWO: EVALUATING THE MENUS

The purpose of the second Phase of the study was to evaluate the effectiveness of the menus derived in Phase 1 of the study.

Participants & Procedures

Thirty-six computer naive participants with no experience using the operating system were randomly assigned to one of three menu conditions. Two of the menu conditions were based on the cognitive representations generated in Phase 1. An alphabetical menu was also used which was considered to approximate learning the operating system by way of a command dialogue. When using this type of dialogue, if a user is uncertain about a command, he references a document which lists the commands in alphabetical order. In the study, the menu took the place of the document. When a user was uncertain about a command name, he referenced the alphabetical menu. For all three menus, every command appeared on one screen.

A paired associates learning task was used to teach the operating system commands. Participants worked to a 90% learning criterion or 4 hours. Participants were presented with a command definition at the top of their CRT and were required to correctly type at the bottom of the screen the name of the command being described. If they were uncertain of the command name, they were instructed to type an asterisk to make the menu appear. The menu also appeared if a participant made an incorrect response.

When the menu did appear, participants chose a command name from the menu and typed it at the bottom of the screen. Participants were allowed three responses before being given the correct answer. Commands were randomly presented in blocks of forty-three trials. A trial consisted of a command definition and the participants response. Participants were allowed rest breaks between blocks.

RESULTS AND DISCUSSION

Drop-Out Rates

The first test performed on the data was to determine if a significantly different number of participants from any of the groups had failed to reach the 90% criterion. A chi squared test indicated that the proportion of participants dropping out was about the same for all groups (Chi-square $(2)=2.6$, $p>.25$).

Response Times and Trials to Criterion

All of the following analyses were performed on data from participants who reached the 90% learning criterion. Table 1 shows the number of participants in each of the groups reaching the various levels of learning.

Table 1. Number of Participants in groups reaching each level of learning.

Group	15	30	45	60	75	90
	Percent of Commands Learned					
Novice Network	11	11	11	10	7	6
Expert Network	14	14	13	12	7	6
Alpha	11	11	10	8	7	4

Note: N = 36 Participants
Total Number of commands = 43

The independent variables were type of menu (novice, expert, or alphabetical) and amount learned. The dependent variables were response time for a correct response when the definition first appeared, response time for a correct response after the menu appeared and the number of blocks to criterion.

The blocks to criterion data was analyzed using the CRISP analysis of variance program. As expected there was a main effect of learning showing that performance improved with practice ($(5,65)=94$, $p<.001$). Table 2 shows the results of the Newman-Keuls multiple comparisons test on this main effect.

Table 2. Mean Number of Blocks And Comparisons for Menu Conditions Collapsed Over Percent Learned.

Group	Mean	Comparison	P Value
Novice Network	3.16	Novice - Alpha	$<.05$
Expert Network	3.69	Expert - Alpha	$<.1$
Alphabetical	5.00	Novice - Expert	$>.1$

A significant interaction between menu type and percent learned was also observed ($F(10,65)=3.6$, $p<.001$). As Figure 1 shows, all groups required the same number of blocks in early learning (ie. at 15% and 30% levels) but as they make the transition to a greater level of learning (ie. at 75% and 90%), the alphabetical menu group requires twice as many blocks as the groups using the menus derived from the expert and naive cognitive networks.

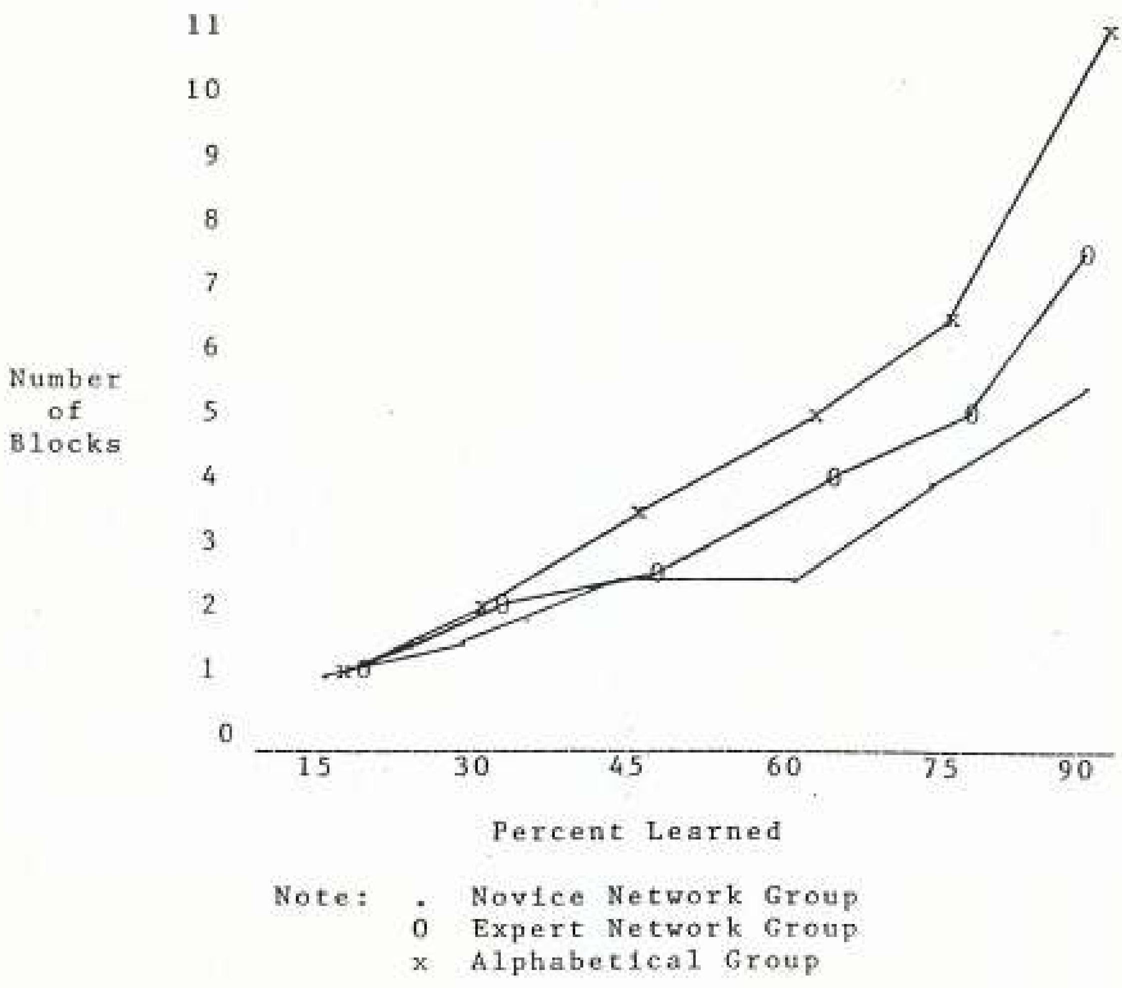

Figure 1. Blocks to Criterion for Participants Learning 90% of the Command Names.

As the graph shows, participants in the groups using the menus generated from the cognitive networks learned 90% of the commands in about five blocks while the group using the alphabetical menu required eleven blocks.

A Newman-Keuls test performed on the data at the 90% learning criterion indicated a significant difference between both cognitive network organizations and the alphabetical arrangement, but not between the cognitive network organizations. These findings are shown in Table 3. This can be interpreted as meaning that the transition from a menu to command dialogue was easier with menus based on cognitive networks derived from novice and expert users.

Table 3. Mean Number of Blocks and Comparisons For Menu Conditions At 90% Learning.

Group	Mean	Comparison	P Value
Novice	5.83	Novice - Alpha	$<.05$
Expert	7.50	Expert - Alpha	$<.05$
Alphabetical	10.75	Novice - Expert	$<.10$

SUMMARY

In conclusion, this study has demonstrated the use of a new technique for designing menus based on cognitive networks. The study has also shown that when compared to an alphabetical arrangement, menus generated from cognitive networks can facilitate transition to a command dialogue by increasing the learning rate.

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