A BEHAVIORAL EVALUATION OF COMMAND-SELECTION AIDS FOR INEXPERIENCED COMPUTER USERS

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INTRODUCTION

The selection and use of commands is one of the most basic skills required for proficiency in a software system. Mastery of the command language, however, is no easy task for inexperienced users. Users must not only learn the names and functions of commands, but must also learn the situations and strategies for using commands in a task. In this dissertation, online aids were designed and evaluated to help novice users in command selection. Specifically, the research assessed the feasibility of online command-selection aids for information retrieval.

Previous research by Elkerton and Williges (1984a, 1985) revealed large differences in the performance and strategies of experienced and novice subjects in a file search task. The results of these studies illustrated that experienced subjects not only used more powerful search procedures, but also used these search procedures quickly in the appropriate situation. In contrast, novice subjects selected a wider variety of search procedures and tended to use search procedures that manipulated the file search display directly. Thus, novices lacked both the knowledge and strategies of file search that more experienced users possessed.

As a result of the observed difficulties in the selection and use of commands, Elkerton and Williges (1984b) implemented an online assistant to aid novice users in file search. The online aid was based on the selection of search commands by experienced users. Essentially, a frequency profile of the search commands selected by experienced users was provided automatically to novices. The results of this research revealed that the frequently selected search procedures of experienced users could serve as a training device, but were severely limited in assisting novices on current information retrieval problems.

Elkerton and Williges (1984b) explained the mixed effectiveness of the file search aid in terms of the limitations of the frequency-based model and the constrained dialogue with the user. The frequency-based model offered only limited information on command selection. Frequency data provided no sequence, planning, or procedural assistance to the novice user. Together with the one-sided, computer-initiated dialogue for offering advice, it was remarkable that novices could use the command frequency information at all.

How can the knowledge and strategy of command selection be conveyed naturally to inexperienced users? Two issues are important in answering this question. First, how should command-selection strategies of novice and experienced users be represented? Second, once strategies are represented, how should the more skilled strategies of experienced users be presented to novice users. The goal of the dissertation, therefore, was to develop and evaluate systematic methods for capturing and presenting the command-selection strategies of experienced computer users to novice computer users.

BACKGROUND

The study of online aids for inexperienced users was motivated by research on intelligent, human-computer systems, research on supporting the learning processes of inexperienced computer users, and the preliminary research of Elkerton and Williges (1984a, 1984b, 1985) on command-selection aids for information retrieval.

Intelligent Human-Computer Systems

The advance of computing technology has, in the last 20 years, introduced the capability for intelligent, human-computer interfaces. Computers are now capable of assisting, instructing, or adapting to individual users (Williges, Williges, and Elkerton, in press) and can no longer be assumed to be passive tools for human use. This development in computing systems has been largely a product of artificial intelligence (Hillman, 1985) and until recently has not been addressed by human factors specialists. However, the need for human factors research to guide the development of these more intelligent interfaces is of great importance.

Unfortunately, there is little human factors data available for research and design of intelligent human-computer systems. To fill this void, human factors specialists should anticipate the technology of artificial intelligence to provide the necessary data to construct effective and intelligent human-computer interfaces.

Clearly, the level of knowledge required for effectively aiding users is an important issue for intelligent interfaces. For example, in the development of expert-consultant systems both Hillman (1985) and Kidd and Cooper (1985) have argued that the success of the system depends on the match between the user's and system's knowledge. Currently, many of the research projects on intelligent interfaces focus solely on developing sophisticated knowledge and reasoning structures. While activity like this is necessary to expand knowledge about intelligent systems, there is the danger that state of the art research on intelligent systems may over design the interface. The philosophy adopted in this research follows the design approach advanced by Williges, Williges, and Elkerton (in press), whereby explicit behavioral objectives are established for the iterative development of a software interface. This method avoids over design and only provides the necessary and sufficient knowledge for aiding or adapting to the user.

In addition to the issues of representing user knowledge and skills, there are questions of how to communicate effectively in an intelligent human-computer system. Indeed, with the introduction of intelligence into the interface a true human-computer dialogue exists and should be investigated thoroughly from a human factors perspective. Of primary importance in intelligent dialogue is the question of control (Rissland, 1984). More specifically, who should initiate the dialogue: the human, the computer, or both.

Learning Support for Inexperienced Users

An understanding of the learning difficulties and processes faced by users of software interfaces may be helpful when designing an online aid. Unfortunately, the learning difficulties and processes that users encounter are very complex. As Mack, Lewis, and Carroll (1983) have described, the user is often overwhelmed by the difficulty of the task, lacks the basic knowledge of computers, often makes *ad hoc* interpretations, frequently generalizes from previous non-computing knowledge, has difficulty following directions, does not understand complex interface features, has trouble using online help, and fails to realize that problems can interact. From this list it is obvious that research addressing the training issues of software interfaces is necessary. However, with all these problems where can online training and user support begin? The work of Carroll and his colleagues on learning by doing, thinking, and knowing (Carroll and Mack, 1984) provides a convenient framework for addressing this question. Put simply, a training interface should support the user in performing the actual computer-based task and should encourage the user to exploit past and current knowledge for understanding the computer system.

Support for learning by doing. Carroll and his colleagues have demonstrated that inexperienced users of computer systems often do not read the documentation or follow the training materials when learning to use a software interface (Carroll and Mack, 1984; Mack, Lewis, and Carroll, 1983). Rather, inexperienced users strike out on their own, learning by doing a computer-based task. Exploiting active learning with a software interface is an attractive embedded training approach. From a psychological perspective, embedded training offers the potential for maximum transfer of training since the stimuli and responses are highly similar in the learning and transfer tasks. Moreover, training individuals during the computer-based task is appealing since meaningful work can be accomplished by the user rather than spending time in a class or reading a manual.

Ideally, the training interface should encourage exploration (Mack, Lewis, and Carroll, 1983) and hypothesis testing (Shrager and Klahr, 1983) by the new user. However, supporting learning by doing is not easy. When exploring the computing environment, inexperienced users of computer systems often commit errors that prevent meaningful learning at the interface. In addition, novice users may get hopelessly lost due to the complexity of the software interface. To circumvent these problems, the interface could be redesigned to block the error states of the novice user (Carroll and Carrithers, 1984) or the software could provide guidance, error correction, and feedback to the novice user (Carroll and Kay, 1985).

The development of a "training wheels" interface by Carroll and Carrithers (1984) attempted to support early learning of a word processor by blocking advanced functions and allowing only the most basic word-processing operations (creating and printing documents). Thus, a new user was able to explore the interface while doing meaningful tasks without entering into exasperating error states. Carroll and Carrithers found that more users of the training wheels interface completed a letter printing task and did so faster than the users of the unmodified word processor. Carroll and Carrithers explained the success of the training wheels design through users gaining feedback when attempting to select blocked functions without suffering the negative consequences of these potential error states. In addition, Carroll and Carrithers noted that the training wheels interface may be a more effective learning environment since the number of system functions was limited and allowed the users to form and test alternative hypotheses about the word-processing system.

Expanding on the success of the training wheels approach, Carroll and Kay (1985) have implemented and evaluated several "scenario machines" where a new user of a word-processing system is guided through a single path or scenario for creating and printing a document. The goal of this research was to determine what combination of user prompting, feedback, and error correction facilitated training and transfer performance in a word-processing task.

Overall, the results from Carroll and Kay (1985) were in agreement with the training wheels research (Carroll and Carrithers, 1984). Scenario machines which guided the user down one path for creating and printing a document reduced training time significantly when compared to a control group that received an unmodified word processor. However, transfer performance on a document revision task was not found to differ between users that received a scenario machine and users that received a full word processor. In fact, the results from the scenario machine with prompting and feedback suggest that some training implementations may be damaging to transfer performance. Specifically, Carroll and Kay (1985) illustrated that a scenario machine with prompts and feedback for user actions may destroy the coherence of the computing task.

As a result of these initial studies, questions about how a training interface should be designed and how the design affects transfer performance still remain unanswered. Clearly, a simplified interface can reduce training for new users, but how does this training affect later performance? The results from the scenario machine research (Carroll and Kay, 1985) suggest that the training interface must be developed carefully so as to avoid changing the computer-based task with the training dialogue. Moreover, it is interesting to speculate whether the simplicity of the training wheels design will help or hinder later performance on a complex computer system. Will gradual exposure in a stagewise fashion facilitate long-term performance or would complete immersion with carefully constructed instruction on the complex computer system be superior? Finally, the time scale of transfer performance also needs to be investigated. Both Carroll and Carrithers (1984) and Carroll and Kay (1984) studied early learning of computer interfaces that did not exceed one day in length. Therefore, design and evaluation of training interfaces should be carried out over a longer time span.

Support for learning by knowing and thinking. In addition to learning by doing, new users spend a considerable part of their time reading and thinking about a software interface. New users are often faced with an enormous amount of information in the form of manuals, online help, and/or tutorials. Integrating this information with any previous knowledge or skills is a complex cognitive task.

Much has been written on the theoretical value of models (Halasz and Moran, 1982), analogies (Rumelhart and Norman, 1981) and metaphors (Carroll and Mack, 1985) for aiding the user to learn and understand a computer interface. For example, Rumelhart and Norman (1981) have suggested that multiple analogies may be useful for explaining the different characteristics of a software interface. Subsequently, Halasz and Moran (1982) argued against this approach stating that multiple, literal metaphors may fail to communicate a consistent structure to new users. Halasz and Moran suggested the use of new and abstract models to present an appropriate conceptual base for reasoning about a computer system. To further complicate matters, Carroll and Mack (1985) recently have argued against both of these approaches stating that metaphors should be used actively, serving to supply users open-ended comparisons suited to their own goals. Specific analogies or conceptual models, Carroll and Mack argue, are passive tools that do not encourage exploration, and therefore, may not be helpful to new users.

What can be gleaned from these opposing theoretical viewpoints? Specifically, three methods for aiding novice users with models, analogies, or metaphors exist by:

1. exploiting prior user knowledge,
2. organizing new interface knowledge, and
3. encouraging user thinking about the software interface.

Initial research on these methods appears to support all three approaches. Consequently, the theoretical efforts, although in conflict, have generated ideas which in practice are useful for assisting and instructing new computer users.

The first method for supporting the user in learning by knowing and thinking rests on developing training and documentation materials that exploit any prior user knowledge. Well placed models, examples, analogies, or metaphors may stimulate the new user to understand the software interface in terms of other familiar objects or tasks. Probably the best support for this method can be found in the research of Mayer (1981) on presenting concrete models for learning programming concepts in BASIC. The concrete model used for BASIC consisted of an input window, a memory scoreboard, a program list and arrow, and an output pad. Comparison of learners receiving a verbal manual with a concrete model of BASIC and learners receiving only a manual indicated that a concrete model could enhance a learner's ability to generate and interpret moderately complex computer code. These transfer problems required learners to go beyond the instructions provided in the manual to create and interpret new programs.

Similar results also were presented by Mayer (1981) for a file-management language with a concrete model consisting of a file cabinet, sorting baskets, a memory scoreboard, and an output pad. Learners receiving the concrete model were better at creating file-management programs that went beyond the simple programs presented in the manual. The conclusions reached from these investigations by Mayer imply that concrete models can be used for enhancing the learner's ability to transfer skills creatively to new and more complex problems. Unfortunately, systematic methods for identifying prior knowledge (scoreboards and file cabinets) still remain to be developed.

Beyond exploiting previous user knowledge, there is also a need for developing procedures to enhance and convey the organization of knowledge surrounding the software interface. Novice users cannot be expected to organize and assimilate every aspect of the software interface. For example, the research of Mayer (1981) has demonstrated that a function of concrete models is to organize the information for easy assimilation. Mayer provided concrete models of BASIC before and after receiving the manual and found an increased recall of technical and conceptual information for the before group. Mayer hypothesized that the increased recall was due to an advanced organizer effect. That is, receiving the concrete model before the manual allowed learners to organize technical and conceptual information in the manual for later recall. Thus, presenting new knowledge to users requires thoughtful organization and sequencing of training materials.

Sullivan and Chapanis (1983) have demonstrated that the new knowledge needed by a user can be organized in a manual using well-known writing principles (e.g., use simple, familiar language and use short active sentences), adhering to systematic task analytic methods (e.g., identify operator tasks and determine sequences of operations), and designing iteratively. The application of these methods resulted in an easy to use text-editing manual, increased the use of text-editing commands, and improved the quality of material copied and edited during evaluation.

Similar results have been found by Foss, Rosson, and Smith (1982) with a text-editing manual that attempted to take into consideration the limited information-processing capabilities of a novice user. Foss, et al. (1982) hypothesized that the original text-editing manual overwhelmed users with too much abstract detail for effective use. The manual for the text editor was rewritten to present only enough information for simple command execution. The increased speed and decreased errors during document editing and creation indicated that manuals can be redesigned effectively from a cognitive perspective emphasizing reduced memory load.

Formal development of principles for effective manual design have also been proposed by Carroll (1984) with the "minimalist" philosophy. In proposing and testing minimal manuals, Carroll has emphasized that manuals should have less text, have a greater task orientation, provide for more learner initiative, provide more error recovery information, and serve as a reference after training. Preliminary testing showed a 40% reduction in training time with the minimal manual.

A final graphical method for organizing knowledge about the user interface has been described by Sebrechts, Deck, and Black (1983). These researchers have developed a diagrammatic approach for describing the knowledge and procedures required for using commands in a software interface. The diagrams proposed were motivated by psychological research on cognitive maps and resembled flowcharts for the selection of commands. Initial evaluation of the flowcharts as an instructional device when compared with a textual manual indicated an increased speed and accuracy for users of the diagrams. Unfortunately, as with the minimal manual (Carroll, 1984), statistical evidence for this evaluation was not available.

From these initial investigations, there appear to be several methods available for organizing the new knowledge required for using a software interface. These techniques ranged from a systems design method (Sullivan and Chapanis, 1982), to a cognitive design approach (Foss, Rosson, and Smith, 1982), to an instructional technology method (Sebrechts, Decker, and Black, 1983). Interestingly, all methods emphasized simplicity when describing the organization of the software interface. Indeed, a motivating factor for using models, analogies, or metaphors for aiding the naive user is the simplification of a potentially complex interface.

However, a simplified model of a software interface could lead to novices failing to learn advanced features of the system. The very low probability that any model can describe all interface features adds to these learning difficulties. Consequently, a third method for helping new users requires the model, analogy, or metaphor to encourage active mental exploration of the software interface (Carroll and Mack, 1985). The benefits of encouraging mental exploration can be seen in the research of Mayer (1981).

Mayer (1981), in addition to studying the effects of concrete models on learning computer programming, also investigated the effects of self-elaboration by the learner. Mayer provided for elaboration in several fashions. First, learners were asked to relate information from the manual to concrete models. Next, learners were asked to compare and contrast programming statements. Finally, learners were asked to take notes on a programming lecture. The results indicated that elaboration increased a learner's ability to transfer programming skills creatively to problems beyond what is covered in a manual or lecture. Moreover, the elaboration activity increased a learner's retention of technical and conceptual information.

To summarize the elaboration research of Mayer (1981), software users should be encouraged to put information in their own words. This may be done explicitly through instructions or through concrete models supplied to the user. Despite these suggestions, however, selection of elaboration procedures is still difficult. Little is known about what type of models, analogies, or metaphors will encourage elaborative processing or whether explicit directions to elaborate will be followed in an actual software interface.

Models for Aiding Information Retrieval

Analysis of the previous topics on intelligent human-computer interfaces and supporting the inexperienced user suggests that methods and procedures for representing information about the user, task, or computer is of prime importance. To aid the inexperienced user, skills and capabilities must be referenced to computer-based procedures. In this research an approximation method was adopted to determine how much and what type of command-selection data must be represented to aid inexperienced users.

Specifically, three levels of command-selection advice were constructed for inexperienced users. The first online aid was based on a frequency profile of the commands experienced users selected. The second online aid was a sequence model of experienced users' transitions from one search procedure to another. Finally, the third online aid was a planning model of experienced users' command selection that attempted to take into consideration the more cognitive aspects of the computer-based task. Progressing from the frequency to sequence to planning models of command selection provides additional and potentially valuable information to the inexperienced user. However, in certain interface design situations, the cost and difficulty of constructing the more advanced command-selection models may be prohibitive. Thus, the intent of the research was to determine what level of command-selection information was useful for aiding the novice user.

Frequency models. One of the most basic models of a user and a task is a frequency profile of command usage. Monitoring the command selection of users has been undertaken previously (Boies, 1974; Good, 1985; Hanson, Kraut, and Farber, 1984; Whiteside, Archer, Wixon, and Good, 1982). However, these efforts have been devoted towards improving the design of conventional software interfaces (i.e., command languages and text editors). In the context of this dissertation, command frequency profiles were used to provide command-selection advice to inexperienced users.

A frequency model has been implemented and evaluated by Elkerton and Williges (1984b, 1985). These investigators found that a profile methodology containing frequency-based information on the selection of search procedures by experienced users could be used to train novice users. The frequency model was an easily constructed performance model that potentially could be used in highly repetitive tasks.

There were some limitations of this modeling approach reported by Elkerton and Williges (1984b, 1985). First, the frequency-based model could not provide command-sequence information. The selection of advice was not sensitive to use of other commands. Second, the model could not supply inexperienced users explanations why a search procedure was suggested or how to use a particular search procedure. Finally, the idiosyncrasies of novice file search could not be accounted for by the model. Inexperienced users that prefer a search procedure and perform adequately with it should be allowed to use it. The model should be capable of learning or adapting to an individual.

Due to these potential limitations, Elkerton and Williges (1984b) describe the file search assistant's communication with the inexperienced user as intrusive since file search efficiency degraded on trials in which advice was given. However, despite these problems the frequency-based model was successful in changing an inexperienced user's search strategy. That is, the frequency-based model was not successful as an assistant, but demonstrated some success as an instructional device.

Why might frequency-based models of command selection be useful for inexperienced users? First, novice users may not need sophisticated methods and advice when using a software interface. Some novices may only require hints or suggestions to break out of inefficient search strategies. Second, frequency-based models are, by definition, incomplete models of command selection, and therefore, encourage the active learning (Carroll and Mack, 1985) and elaborative processing (Mayer, 1981) that are useful when learning a software interface.

Sequence models. As noted by Elkerton and Williges (1984b) sequence information is one potential improvement over a frequency-based model. These models attempt to capture the context of command selection by considering past and present commands in predicting future commands. A good example of the potential for including sequence information exists in hierarchical file-management tasks. Spine, Whiteside, and Williges (1984) and Hanson, Kraut, and Farber (1984) demonstrated that users frequently follow a command to move to a new directory by a command to list the files in the new directory. Sequence information such as this would be valuable to inexperienced users who are attempting to navigate and find information in a hierarchical file system.

As with analysis of frequency data, sequence analysis has aimed primarily at the design of conventional human-computer interfaces. These research endeavors include the analysis of keystroke and state transitions in text editing (Whiteside, Archer, Wixon, and Good, 1982), command transitions in an operating system (Hanson, Kraut, and Farber, 1984) and the Markov processes of selecting database retrieval commands (Penniman, 1975). These investigations have shown a variety of methods for representing and analyzing sequence information. The most basic form of sequence information is contained in a transition matrix which lists the probability of moving from one command to another at some future point in the dialogue. As illustrated by Whiteside, Archer, Wixon, and Good (1982) various orders of transition matrices can be constructed to predict beyond the next keystroke or editing state. In addition, Hanson, Kraut, and Farber (1984) have shown that transition matrices may also be subjected to multivariate statistical procedures like hierarchical cluster analysis and principal components analysis to extract important sequence structures in command usage.

Before implementing empirical sequence models for aiding novice users, research must be undertaken focusing on the benefits over frequency-based representations. The additional cost and time of a sequential analysis may not be justifiable in some applications. In addition, from a behavioral perspective sequence models may be difficult to comprehend by the user. Adding sequence information increases the complexity of the model by the square of the number of commands in a frequency model.

Planning models. The third model for assisting and instructing users goes beyond empirical sequence representations by making assumptions about the cognitive processing of the user. The construction of plan-based models assumes that inexperienced users must problem solve with computer-based procedures. To use Norman's (1984) four stages of user activity, the inexperienced user must form mental intentions and actions, execute these plans with automated procedures, and finally evaluate the result.

Norman (1984) suggests a variety of conventional methods like memory aids, menus, and workbenches, to support user stages. However, in this dissertation the development of plan-based models for assisting and instructing inexperienced users focused on the selection and execution of actions. The importance of aiding action selection and execution is underscored by the error rate during these stages. In the UNIX screen-based text editor, Riley and O'Malley (1984) have estimated from empirical data that 58% of user errors could be categorized as selection and execution errors. Therefore, as Jackson and Lefrere (1984) suggest, a plan-based system should be capable of criticizing and providing developmental support for a user's selection and execution of plans.

What is a plan? Briefly, a plan can be conceived of as a series of mental steps towards the solution of a problem (Schank and Abelson, 1977). The steps are defined as cognitive activity in an attempt to describe the underlying processes of behavior. Homogeneous chunks of mental behavior can be captured in plans for specific circumstances and individuals. Card, Moran, and Newell (1983) and Robertson and Black (1983) have both demonstrated that plans are cognitive entities chunked together in temporal and functional sequence. This chunking of mental behavior often results from the individual facing large, complex problems that are too difficult to be solved with one mental operation. To overcome these short-term memory constraints, the learner often employs a "divide and conquer" strategy, planning problem solving as small sets of subtasks (Card, Moran, and Newell, 1983).

As a consequence of the cognitive nature of plans, these models of behavior will always be approximate. Plans cannot be observed directly. However, different planning processes do exist and need to be understood before models can be built for aiding novice users. The three types of planning processes that may influence the development and implementation of planning models include:

1. compiled planning,
2. well-specified planning, and
3. opportunistic planning.

Compiled planning is linear in nature. An individual selects a well-practiced method for achieving a goal and executes the method without interruption. Compiled planning resembles the automatic processing elaborated on by Schneider and Shiffrin (1977) and the script-based processing described by Schank and Abelson (1977). A compiled plan requires little attention for execution and exploits task-specific knowledge learned through extensive practice.

Examples of compiled plans abound in the use of computer-based systems. One plan that most users compile is the command sequence for logging on to a computer system. At first, the logging sequence may be a difficult problem-solving task (Carroll and Mack, 1984). However, with practice the user internalizes the sequence and executes it without thinking. Recent research suggests that experienced users may develop and exploit compiled plans in domains such as programming (Ehrlich and Soloway, 1984) and text editing (Card, Moran, and Newell, 1983; Robertson and Black, 1983).

Well-specified planning can be distinguished from compiled plans in that the sequence of mental operators must be decided upon explicitly rather than existing as a coherent sequence of mental operations. Consequently, the controlled processing (Schneider and Shiffrin, 1977) of well-specified plans requires substantial mental workload during plan formation. Circumstances requiring well-specified planning include critical instances where mistakes can be disastrous and complex or novel problems where planning will speed solution.

While the two previous planning models focused almost entirely upon plan formation and execution, opportunistic planning focuses to a greater extent on plan evaluation and revision (Hayes-Roth and Hayes-Roth, 1979; Jackson and Lefrere, 1984). With opportunistic planning, humans are assumed to be using the information acquired during plan execution to monitor and revise plans. Thus, opportunistic planning is much more dynamic than compiled or well-specified planning. Data supporting opportunistic planning in computing systems can be found in text-editing behavior. By analyzing command transitions, Whiteside, Archer, Wixon, and Good (1982) have revealed that users frequently alternate between text-editing subtasks. After leaving an editing state, users tend to return to it after a single intervening state.

Research efforts devoted to developing planning aids for users of computer systems have attempted to support all three planning processes (compiled, well-specified, and opportunistic). The help system described by Finin (1982) attempted to diagnose the sometimes opportunistic and potentially erroneous command sequences of inexperienced users of a computer operating system. For example, if a user attempted to erase all previous versions of a file by using multiple DELETE commands, then the planning aid would suggest use of the PURGE command. Similar help and advisory systems have been implemented for computer-aided design (Cullingford, Krueger, Selfridge, Bienkowski, 1982), file management in UNIX (Wilensky, Arens, and Chin, 1984), and automated symbolic integration with MACSYMA (Genesereth, 1982). The goals of these planning systems have not been to identify and research specific planning processes, but to provide context-sensitive advice without overburdening the short-term memory constraints of the user (Darlington, Dzida, and Herda, 1983).

To identify and support compiled, well-specified, and opportunistic planning will require the construction of systematic methods for extracting plans from computer users. Briefly, the method for extracting information will depend on the planning process. For instance, extracting compiled plans from users will probably depend on performance methodologies like path analysis (Alty, 1984, Tolle and Hah, 1985), or chronometric analysis (Robertson and Black, 1983). The reason for relying on performance rather than more subjective verbal reports rests in the information processing of compiled plans. As stated earlier, compiled plans are executed in an automatic fashion (Schneider and Shiffrin, 1977) and may not enter short-term memory. Computer users may not be able to report compiled plans accurately (Ericcson and Simon, 1984).

In contrast, well-specified plans are under the direct controlled processing of the user and will result in the information being attended to in short-term memory. Verbal report procedures (Ericcson and Simon, 1984), structured sorting procedures (Tullis, 1985), or similarity rating procedures (Kay and Black, 1984) may be used to extract this information from a user's memory.

Finally, opportunistic planning poses difficulties for both performance and subjective assessment since users may not have established plans for many computing tasks. The designer of planning models probably will have to adopt a formal, analytical method for constructing these plans using subject matter experts (e.g., Card, Moran, and Newell, 1984).

Dialogues for Aiding Information Retrieval

Once knowledge has been captured and represented in a software interface, it must be presented to the user. However, before presenting command-selection information to inexperienced users, decisions must be made on who should control the dialogue. In this dissertation, the three dialogue initiatives to be evaluated for an online aid are user-initiated, computer-initiated, and mixed-initiated (both user- and computer-initiated) dialogues. Only limited human factors data exists for implementing these dialogues. The conventional wisdom has been to provide the user with control of the dialogue (Williges and Williges, 1984). However, the assumption of user control may be open to question with the increased intelligence in software interfaces and the increased emphasis of online training for inexperienced users.

User-initiated dialogues. With an online aid or help, some evidence does exist for providing standard user-initiated dialogues. For example, Cohill and Williges (1985) evaluated eight online help conditions by manipulating the initiation of help (user versus computer), the selection of help topic (user versus computer), and the format of help (online versus hard copy). From this experiment, Cohill and Williges found that user initiated and selected help facilitated browsing and exploration by the user. Furthermore, user initiated and selected help decreased the total time on the editing task, errors, and command use when compared to other help groups and a control group that did not receive help information. From this investigation, the need for user-initiated dialogues is clear. Computer users are well aware of their difficulties and, if provided a well-designed help system, can search and discover the information required to solve a computing problem.

Computer-initiated dialogues. However, there are times when users may not know of their computing shortcomings. Indeed, the research of Elkerton and Williges (1984b) on file search assistance revealed the search strategies used by inexperienced users can be improved. Unfortunately, the cost of improving file search strategies was large in terms of the intrusiveness of the online assistant. The online command-selection assistant implemented by Elkerton and Williges (1984b) increased task times when advice was given. Clearly, computer-initiated dialogues can be disruptive to the current computer-based task.

Nevertheless, as Burton and Brown (1982) have shown, the benefits of computer-initiated dialogues can be great if the conditions for interrupting the user are carefully selected. Burton and Brown (1982) in providing advice to students for WEST (a game to teach basic arithmetic skills) implemented an advisor that was forgiving and only provided advice when absolutely necessary. More specifically, the computerized advisor only gave advice when the students were weak in a specific arithmetic skill and if an appropriate example was available. The advisor did not give advice consecutively or when the user committed careless errors. Descriptive statistics indicated an increased use of optimal arithmetic strategies and skills with the computerized advisor. However, inferential statistics were not provided by Burton and Brown (1982). Further research is required to determine whether computer-initiated advice can be beneficial to improve the skills of users who may be unaware of superior computer-based methods.

Mixed-initiated dialogues. Together, the capability of the computer offering advice and the user having the opportunity to ask for advice is an appealing mixed dialogue. In skill acquisition, mixed-initiative dialogues could be valuable for suggesting more powerful automated procedures and providing for times when the user is at a loss for a method and must request help. Likewise, mixed-initiative dialogues in information retrieval may be valuable for calling attention to data that could be ignored by the user (Ehrenreich, 1981). Despite these potential advantages and several implementations of mixed-initiative dialogues (Cullingford, Krueger, Selfridge, Bienkowski, 1982; Finin, 1982; Grignetti, Hausmann, and Gould, 1975; Wilenski, Arens, and Chin, 1984), the behavioral efficacy of these dialogues is unproven.

PURPOSE

The background literature on intelligent interfaces and previous research by Elkerton and Williges (1984b, 1985) suggested that models and dialogues are important factors when designing an online aid for inexperienced computer users. Therefore, the goals of this investigation were to develop and evaluate frequency, sequence, and planning models of information retrieval to be used as active learning aids with computer-, user-, and mixed-initiated dialogues.

Development and evaluation of these active learning aids required two experiments. The first experiment was devoted to model development and focused on the construction of the frequency, sequence, and planning models of information retrieval. This model development experiment required the identification of performance differences in information retrieval for novice and experienced users, as well as the systematic construction of command-selection models based on frequency, sequence, and planning data.

The second experiment implemented and evaluated the command-selection aids for inexperienced users. This experiment attempted to describe any changes in behavior that occurred as a result of receiving the online aids with the computer-, user-, or mixed-initiated dialogues. Information retrieval performance, strategy, and subjective evaluations were collected from the aided users to determine which model and dialogue were least intrusive and possibly beneficial when provided to novices. Moreover, performance and strategy were also monitored in a final unaided session to determine any possible transfer of training for the three models.

EXPERIMENT 1: DEVELOPMENT OF THE COMMAND-SELECTION MODELS

Approach

In addition to the expert-novice performance differences which had to be demonstrated in this experiment, both the knowledge and skills of the information retrieval task had to be extracted from the more experienced subjects. Extracting information retrieval knowledge focused on identifying the important and meaningful aspects of the task from a user's perspective. The knowledge extraction techniques sought to identify common sets of information retrieval problems through the use of psychological sorting and statistical clustering procedures. The sorting and clustering procedures were used to suggest a task organization that would be the basis for development of the three command-selection models. These sorting and clustering procedures served to generalize the command-selection models so that specific advice was not required for every information retrieval problem.

The model development activity in this experiment concerned the construction of the frequency, sequence, and plan-based command-selection models. Conceptually, these three models attempted to capture the information retrieval skills of experienced users at three distinct levels. The frequency and sequence models are performance-based representations that are incomplete, but simple to construct models of command selection. The plan-based model is more complete in describing both a sequence of search procedures and a verbal description of the search processes to be used during command selection. The planning model attempts to capture the more cognitive aspects of the information retrieval task and as a result is more difficult and time consuming to construct. Both the methodological details for constructing the models and the differences between novice and experienced users for the specific information retrieval task are described in this experiment.

Method

Subjects. Twenty-six university students volunteered and were paid $50.00 for participating in the experiment. Of these subjects, 12 were classified as experienced and 14 as novice computer users. Two of the novice subjects were excluded from the experiment for failure to meet training criteria yielding a novice sample size of 12.

Subject classification was based on previous background experience with computers. Experienced subjects (hereafter referred to as experts) were required to have at least two years of experience using interactive computer systems, while novice subjects were required to have less than 20 total hours of experience on any interactive computer system. The background information presented in Table 1 illustrates the advanced computer training of the expert subjects and the relative lack of computing experience for novice subjects. In addition to these experience criteria, all subjects were required to complete and score 70% on a recognition test of the information retrieval database and to be capable of finding information in less than 300 seconds (average) at the end of training. Of the two novices excluded from the experiment for failure to meet these criteria, one novice could not find information fast enough and one novice was not familiar with the information retrieval database.

All subjects were screened for 20/30 visual acuity and familiarity with a Qwerty keyboard. The vision test was administered with a Bausch and Lomb Vision Tester. All subjects indicated that they understood their rights as research participants by signing an informed consent form (see Appendix A) before the start of the experiment.

TABLE 1

Background Experience of Subjects in Experiment 1

Background Variable	Median	Range
Experts		
Number of courses using interactive systems	8.5	2 - 15
Hours/day using the computer	3	1 - 7
Number of interactive editors used	4	2 - 7
Number of other software products used (databases, spread sheets, etc.)	2.5	0 - 8
Non-academic experience with interactive systems	11 of 12 experts	
Novices		
Number of courses using interactive systems	1	0 - 2
Total hours using the computer	10	6 - 20
Number of interactive editors used	0	0 - 1
Number of other software products used (databases, spread sheets, etc.)	0	0 - 2
Non-academic experience with interactive systems	3 of 12 novices	

File hierarchy. The information retrieval task in this experiment required subjects to retrieve information from 15 files arranged in a three-level hierarchy. A diagram of this file hierarchy is shown in Figure 1. The 15 files in the hierarchy contained both textual and numerical data on army operations, tanks, armored personnel carriers (APCs), and combat support. Tables, hierarchies, lists, and paragraphs were used to structure the information in each file. In total, the database contained 2780 lines with individual files having from 55 to 447 lines. Portions of the 15 files in the database are presented in Appendix B.

As mentioned earlier, all subjects were given a recognition test on the file hierarchy and file content to assure a basic understanding of the database. The recognition test was a two-part test. The first part of the test required subjects to place file labels on an empty diagram like that shown in Figure 1. In this test, subjects were given 27 file labels (15 correct labels and 12 foils) and instructed to place the file labels in the correct position on the empty file diagram. The second part of the recognition test required subjects to complete a 14 question multiple-choice test on database content (Appendix C). Subjects were not allowed to view the file hierarchy during this test. A combined test score of 70% was required of each subject.

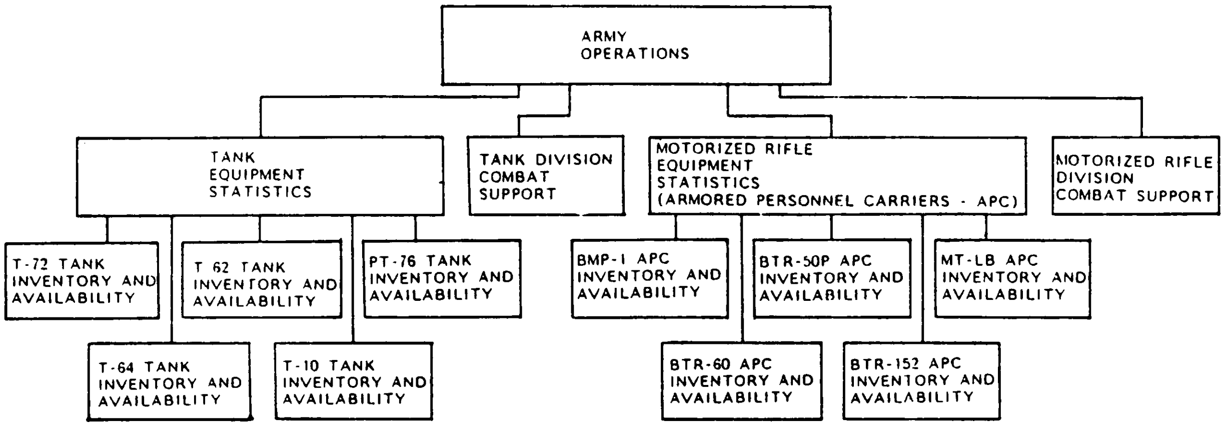


Figure 1. <u>File hierarchy for the file selection and search task</u>.

Information retrieval hardware and software. The information retrieval system which displayed data in the file hierarchy was written in FORTRAN and implemented on a VAX 11/750 computer running the VMS operating system. An elevated time-sharing priority was used during the experiment to maintain the speed and accuracy of the retrieval environment. Two Digital VT100s were used for the information retrieval experiment. The primary VT100 was used for displaying the database, while the secondary VT100 was used for presenting the search problems. The primary display, as shown in Figure 2, contained a 7-line window based on the results of Elkerton and Williges (1984a), a file status line, an input and message line, a work area, and a touch keypad. Subjects selected search procedures through the touch keypad that was implemented with a Carroll Technology touch-entry device. These 12 search procedures manipulated the database through the 7-line window. Subjects used a VT100 (Qwerty) keyboard for data entry with some of the search procedures. Finally, subjects were monitored on their retrieval behavior through embedded performance measurement (Cohill and Ehrich, 1983).

Search procedures. The 12 search procedures that subjects were provided on the touch keypad contained file selection procedures (ZOOM IN, ZOOM OUT, and FILE SELECT),

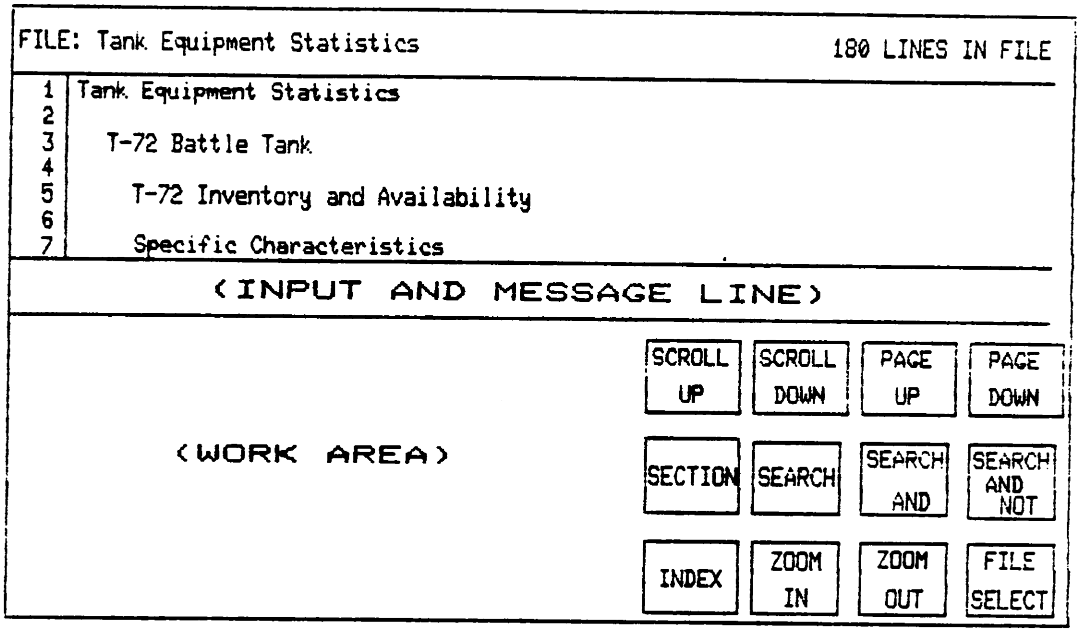


Figure 2. Primary display for the file selection and search task.

ballistic search procedures for large movements within a file (SECTION, SEARCH, SEARCH-AND, SEARCH-AND-NOT, and INDEX), and fine adjustment search procedures for small movements within a file (SCROLL UP and DOWN, PAGE UP and DOWN).

The file selection procedures, ZOOM IN, ZOOM OUT, and FILE SELECT, were used exclusively for traversing the file hierarchy. The ZOOM IN and ZOOM OUT procedures updated the current file in the 7-line display window by moving up and down the file hierarchy (Figure 1). Subjects could use the ZOOM IN procedure to move down the file hierarchy whenever a highlighted line appeared in the 7-line window. Highlighted lines were the file topics in the hierarchy and were embedded in each of the parent files of the hierarchy. Thus, a highlighted line meant that more information could be retrieved on a specific topic like TANK DIVISION COMBAT SUPPORT. In contrast, the ZOOM OUT procedure could be used to move up the file hierarchy. Lastly, the FILE SELECT procedure was used for selecting the files more directly. FILE SELECT allowed subjects to select all files below the current file in the hierarchy through menu selection.

The ballistic search procedures consisted of search procedures that supplemented the organization of the current file (SECTION and INDEX) and string search procedures

(SEARCH, SEARCH-AND, and SEARCH-AND-NOT) for electronically scanning the current file. The SECTION procedure exploited and presented the hierarchical structure of each file in the 7-line window. The SECTION procedure presented a menu of sections and subsections to the subject in the work area of the primary display. Choosing one of these sections would position the current file at the appropriate location in the 7-line window. Conceptually, the SECTION procedure resembled a table of contents.

The INDEX procedure also used the work area of the primary display when presenting an alphabetical list of topics and subtopics for the current file. The subject could browse through this list and select topics of interest. The INDEX procedure would then present a set of locations in the file where the topic was located that the subject could scan quickly. In design, the INDEX procedure was modeled after a book index.

The string search procedures (SEARCH, SEARCH-AND, and SEARCH-AND-NOT) permitted the subjects to look for specific textual strings in the current file. All string search procedures would fill a 10-location buffer which could be scanned by the subject. The SEARCH procedure was a single string search, whereas the SEARCH-AND/SEARCH-AND-NOT procedures were multiple string searches with Boolean operators. The SEARCH-AND procedure allowed subjects to look for several textual strings within one window (7-lines) of each other. The SEARCH-AND-NOT procedure could be used to search for a textual string (or strings) without the occurrence of another textual string (or strings).

The fine adjustment procedures moved the current file through the window either one line at a time (SCROLL UP and DOWN) or seven lines at a time (PAGE UP or DOWN). Both the scrolling and paging procedures could be used continuously.

Procedures for information retrieval. Data collection for each subject was conducted in 6 sessions over a time span of 5 to 7 days. Individual sessions were scheduled so that there was no less than 6 hours and no more than 48 hours between sessions. For the most part, however, subjects scheduled one session on 6 consecutive days. The extended time period of the experiment was required to train and observe subjects learning to use a software interface in a complex problem-solving task. A summary of the activities and approximate times during these 6 sessions is provided in Table 2.

The first two sessions shown in Table 2 were devoted to training and practice on the information retrieval system. In Session 1, all subjects first received preliminary instructions on the experiment and tasks (Appendix D). All

TABLE 2

Experimental Times and Procedures

Task	Time (in minutes)
Session 1: Training	
a. Introduction to experiment	10
b. Tutorial on database	20
c. Break	5
d. Tutorial on search procedures: SCROLL to SEARCH-AND-NOT	55
e. Break	5
f. Tutorial on search procedures: INDEX to FILE SELECT	30
Total:	125
Session 2: Practice	
a. Reexamination of database and search procedure reference sheet	10
b. Individual search procedure review	15
c. 12 practice trials: all search procedures available	30
d. Break	5
e. 12 practice trials: training assessment	20
f. Break	5
g. Database recognition tests	10
Total:	95

TABLE 2

Continued

Session 3 - 5: Information Retrieval	
a. 4 warm-up trials	5
b. 12 experimental trials	20
c. Break	5
d. 12 experimental trials	20
Total:	50

Session 6: Information Retrieval and Sorting Procedures	
a. 4 warm-up trials	5
b. 12 experimental trials	20
c. Break	5
d. 12 experimental trials	20
e. Break	5
f. Sorting of search problems	60
Total:	115

of the instructions and training given in Session 1 were administered interactively by the computer. Specifically, instructions were presented visually on a third Digital VT100, while a Digital DECtalk text-to-speech synthesizer repeated the instructions verbally.

Following these introductory remarks, all subjects were introduced to the information retrieval database. An online tutorial explained both the structure and the content of the file hierarchy. The tutorial briefly summarized the important aspects of each file with regards to the type of information (e.g., verbal or numerical) and the file structure. While reading and listening to this tutorial, subjects were encouraged to locate the file on the file diagram (Figure 1) and to locate important information in an outlined and highlighted hard copy of the database. The hard copy of the database was available only during this tutorial, while the file diagram was available throughout Session 1. The text for this online tutorial is provided in Appendix E.

After being familiarized with the information retrieval database, subjects were asked to take a 5 minute break. Immediately after this break, all subjects were introduced to the information retrieval system by an online tutorial. The structure of this tutorial on search procedures was to first explain both the function and use of each search procedure separately. Intermixed in these explanations were actual information retrieval problems for subjects to solve that demonstrated small components of each search procedure. Following these explanations would be two additional search problems for the subject to solve using only the search procedures just explained. Both the text and the search problems used in the tutorial are given in Appendix F.

At all times the tutorial emphasized that subjects should see the experimenter when encountering difficulty on a search procedure. Furthermore, repeat displays of the tutorial and information retrieval system were monitored in a separate room allowing the experimenter to determine if there were any major difficulties during training. Finally, all subjects had a short search procedure reference sheet (see Appendix G) which briefly explained the use of each search procedure. This search procedure reference sheet was available throughout the experiment.

In Session 2 of the experiment, all subjects were given the opportunity to practice the search procedure skills acquired in Session 1. First, subjects were given a short time to reexamine both the database and the search procedure methods. This was followed immediately by a procedural review of the search procedures. In this review, subjects were asked to solve the same search problems administered in the Session 1. After refreshing their memories on the search procedures, subjects were given 12 new search problems. Subjects were encouraged during these trials to explore the different search procedures. During these trials, the experimenter was available for questions. Moreover, if the subject did not interact with the information retrieval system for more than 2 minutes, the experimenter entered the experimental room and asked whether the subject had any questions.

Following the initial whole training (all search procedures available) subjects were given a 5 minute break, followed by an additional 12 search problems. Before beginning these 12 search problems, subjects were instructed that the experimenter would not be available for questions and that they were to retrieve the information as fast as possible. Based on pretesting, an average of 300 seconds was set as the upper time limit for all subjects during these trials. Both this performance test and the subsequent test on the database were required to insure that all subjects had basic information retrieval skills.

As shown in Table 2, all subsequent sessions (3 - 6) involved information retrieval. Subjects during these sessions received 5 warm-up trials, followed by 24 search problems that were split into 2, 12-trial blocks separated by a 5-minute break. Consequently, subjects received 96 search problems (Appendix H) on which performance was analyzed. On these 96 trials subjects were asked to find the information as fast as possible.

The presentation order of the 96 search problems was randomized with two restrictions. The first restriction required that presentation order be matched for novices and experts. This prevented any presentation orders differentially biasing the performance of either subject group. The second restriction required that a set of search problems be randomly selected for Session 6 and the presentation order be randomized separately from the other sessions. This restriction was required to later compare transfer performance of the advised subjects in Experiment 2 with the performance of subjects in Experiment 1.

Procedures for sorting search problems. As illustrated by Table 2, the key difference between Sessions 3 - 5 and Session 6 was the presence of the sorting procedures at the end of Session 6. In these procedures, both novice and expert subjects were asked to sort the 96 search problems into meaningful categories. The sorting procedure was a variant of the two-level sorting method used by Tullis (1985) to structure a menu operating system.

To sort the search problems, subjects were seated at a desk with the 96 search problems typed on index cards. Subjects then were given written instructions (see Appendix I) on how to sort the search problems. During the first sorting phase, subjects were instructed to place the search problems into meaningful groups. No restrictions were placed on the number of groups or number of search problems in each group. However, subjects were told to supply on a separate index card: (1) a list of group characteristics or a reason why the search problems were classified together, and (2) a possible sequence of search procedures (a search plan) for locating that type of search problem. Subjects were allowed as much time as possible to complete the first sorting phase, however, most subjects finished in under 60 minutes.

In the second phase of sorting, subjects were to perform the sorting process once more. That is, subjects were asked to sort the groups of search problems generated in the first sort into more general categories and to provide a short description of these more general categories. Subjects were not allowed to restructure the groups from the first phase and were given as much time as necessary to complete the second sort. Most subjects finished the second sorting phase in approximately 10 minutes.

As a result of these two sorting phases, subjects formed a two-level hierarchy of search problems that could be scored using a procedure described by Tullis (1985). Specifically, a 96 X 96 distance matrix was constructed by adding a 0, 1, or 2 to each cell indicating the similarity of two search problems for each subject. A 0 was added to the appropriate cell if the two search problems appeared in the same group at the end of the first sorting phase. A 1 was added to the appropriate cell if the two search problems were not in the same group after the first sorting phase, but appeared together in a more general group after the second phase of the sorting procedure. Finally, a 2 was added to the appropriate cell if the search problems appeared in no group together. In other words, the 0, 1, or 2 was a simple metric for describing group membership of the search problems in the two-level hierarchy for each subject.

A two-level sort was selected for two reasons. Most importantly, the two-level sort generated a hierarchical structure that was consistent with the hierarchical database. Second, a two-level sort allowed subjects more than one chance to use different criteria in sorting the search problems (Rosenberg and Kim, 1975). Clearly, there were several dimensions on which search problems could be classified. Subjects, for example, could sort search problems based on the type of search strategy required, the location in the database, or the type of numerical or verbal information requested. A two-level sort made it possible to identify and structure these dimensions.

Results and Discussion

Search performance. Search performance was analyzed for the total number of search operations, number of different search operations used, total time in seconds, and total file movement through the display window corrected for the minimum movement to a search problem (in lines). A multivariate analysis of the novice and expert means for these dependent measures indicated that there were statistically reliable differences in overall search performance, Hotelling's $T^2 = 15.94$, $F(4,19) = 3.45$, $p = 0.0281$. Box plots of the means for the four dependent variables are presented in Figure 3. Represented in each of these box plots are the interquartile range (the outer edges of each box), the median (the middle line in each box), the mean (the asterisk in each box), and the data points falling outside the interquartile range. Figure 3 shows the differences in mean search performance between novices and experts and also the differences in the search variability of the two groups. That is, novices were slower and more

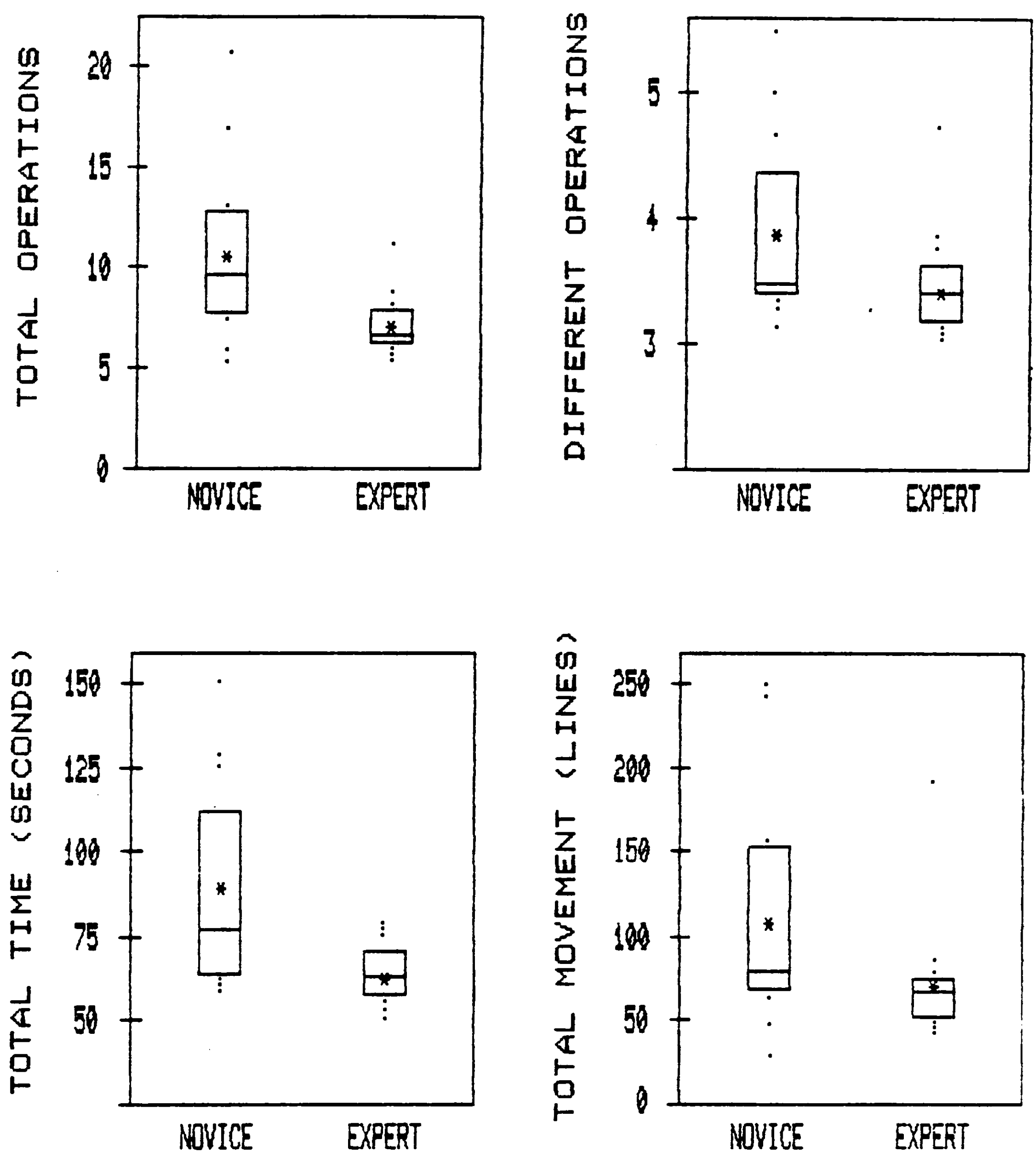


Figure 3. Effect of subject experience on search performance.

variable in locating information in the database than expert subjects.

Separate two-way, analyses of variance (ANOVAs) were conducted on these dependent measures to determine if there were any mean search differences that could be detected for novices and experts across the four retrieval sessions. Summaries of these and all other ANOVAs are contained in Appendix J. The results of the four ANOVAs revealed statistically reliable differences between novices and experts for total operations ($\underline{F}[1,22] = 6.04$, $\underline{p} = 0.0224$) and total time ($\underline{F}[1,22] = 8.59$, $\underline{p} = 0.0077$). From these analyses and the means plotted in Figure 3, novices appear to take more time and search operations to find information when compared to experienced subjects.

The four ANOVAs on search performance also revealed highly significant session effects for total operations ($\underline{F}[3,66] = 11.07$, $\underline{p} = 0.0001$), different operations ($\underline{F}[3,66] = 6.42$, $\underline{p} = 0.0008$), total time ($\underline{F}[3,66] = 20.73$, $\underline{p} = 0.0001$), and total movement ($\underline{F}[3,66] = 4.91$, $\underline{p} = 0.004$). These session effects indicate that subjects were learning how to retrieve information in this complex task. However, the lack of any significant session by subject experience interaction ($\underline{p} > 0.05$) indicates that both novices and experts were learning at the same rate.

Unfortunately, many of the above results are suspect due to the large differences in variability between novices and experts. To analyze search performance variation of novice and expert subjects, a non-parametric, Moses rank-like test (Hollander and Wolfe, 1973) was conducted. A nonparametric test was chosen to be conservative in making assumptions about the underlying search distributions. As a result of these tests, significant differences in search performance variability were found for total operations ($\underline{W}[4,4] = 25.0$, $\underline{p} = 0.029$), and total time ($\underline{W}[4,4] = 26.0$, $\underline{p} = 0.014$). The magnitude of these differences were enormous both from observation of Figure 3 and the variances of total operations (novices, $\sigma^2 = 19.42$; experts, $\sigma^2 = 2.54$) and total time (novices, $\sigma^2 = 869.28$; experts, $\sigma^2 = 80.42$).

Further inspection of search performance in Figure 3 provides additional insights into the large differences in variability among novices. For instance, if all novice search distributions are halved at the median, comparisons of the fast and efficient novices with the experts would yield no differences. Comparisons of the slow and inefficient novices with the experts, however, would lead to large differences. Simply put, two different types of novice users may have been sampled in this experiment. Unfortunately, the lack of any significant correlation

(Spearman's rank correlation coefficient, $p < 0.05$) between background variables and any search performance measure prevented the formation of data-driven hypotheses on the underlying characteristics that separate novice users.

Nevertheless, examination of the search performance for "slow" novices, "fast" novices, and experts over the experimental sessions were useful to identify differences in the learning curves that could affect the implementation of the online aid. To conduct these analyses, novice subjects were divided equally into a slow group (6 subjects) and a fast group (6 subjects) based on average time. Four separate ANOVAs with unequal cell sizes were employed for each dependent measure using the method of weighted means (Winer, 1971).

Not surprisingly, highly significant subject group effects were found for total operations ($F[2,21] = 14.26$, $p = 0.0001$), different operations ($F[2,21] = 7.50$, $p = 0.0035$), total time ($F[2,21] = 27.86$, $p = 0.0001$), and total movement ($F[2,21] = 8.61$, $p = 0.0019$). In addition, much like the previous balanced ANOVAs, highly significant session effects were found for total operations ($F[3,63] = 11.24$, $p = 0.0001$), different operations ($F[3,63] = 6.14$, $p = 0.0011$), total time ($F[3,63] = 21.17$, $p = 0.0001$), and total movement ($F[3,63] = 4.32$, $p = 0.0079$)

without any significant ($p < 0.05$) subject group by session interactions. All of these results are summarized in Figure 4 which displays the average search measures for all three subject groups (slow novices, fast novices, and experts) over all sessions. Surprisingly, Figure 4 shows how closely fast novices resembled experts in search performance throughout the experiment. These two subject groups (fast novices and experts) were significantly faster than slow novices at all phases of the experiment (Newman-Keuls, $\alpha = 0.05$).

The results of these analyses on search performance demonstrated that the differences between novices and experts existed both in terms of average search performance (total operations and time) and the variability in search performance. However, both the average and variability differences are closely related since the slower novices strongly influenced the overall mean search performance of the group. As a result, the goal of online aiding with this information retrieval task should be to assist and instruct those novice users having difficulties locating information without interfering with novices that are performing adequately. The implications for this type of online aid can be viewed from both an individual and a group perspective. For specific individuals, online aiding may

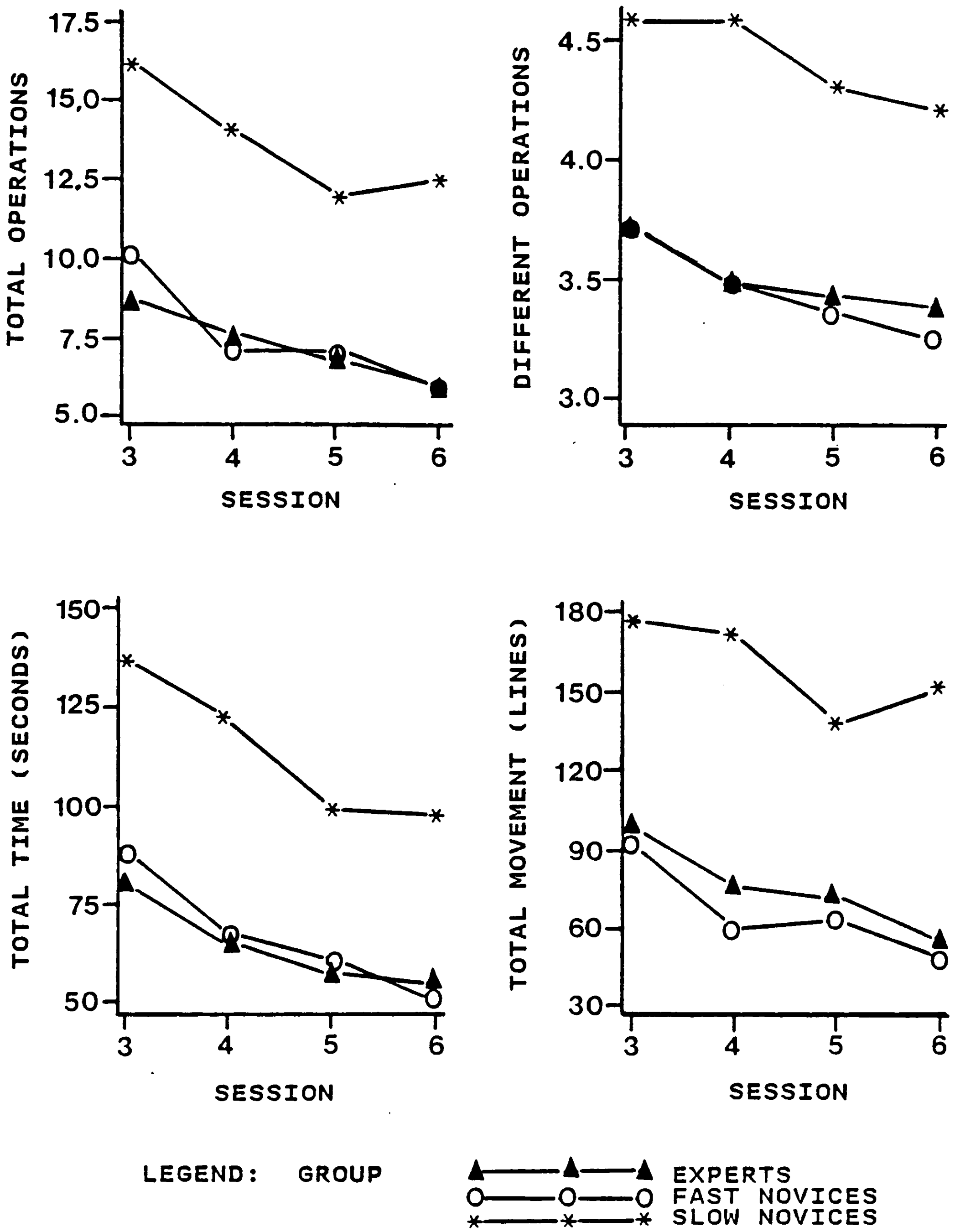


Figure 4. Search performance for fast novices, slow novices, and experts over sessions.

improve their performance so that the automated system can be used for real tasks. From a group perspective, online aiding may yield a more homogeneous group of users that would be easier to support and/or train. Both of these goals are important and have been stated in other research areas such as computer-assisted instruction (Atkinson, 1972).

The search performance results were also interesting since the novice-expert differences resembled some of the empirical data on acquiring high-performance skills (Schneider, 1985). For example, the high degree of heterogeneity in novice search performance has been found frequently when training other high-performance skills. Thus, the heterogeneity of novice search performance may not just be a statistical artifact that should have been controlled, but a real phenomenon resulting from a highly structured and complicated task.

Search strategy. Selection of search procedures by novice and expert subjects was analyzed based on a polling procedure developed by Elkerton and Williges (1985). A diagram of this polling procedure for a hypothetical subject is presented in Table 3. Conceptually, a subject on each trial was given a vector of 12 votes representing the 12 search procedures. A vote was cast for a search procedure

TABLE 3

Polling Procedure for a Hypothetical Subject

SEARCH PROCEDURES	SEARCH PROBLEMS						TOTAL POLLS
	1	2	3	. . .	95	96	
SCROLL UP	0	0	0		1	0	37
SCROLL DOWN	1	1	0		0	0	41
PAGE UP	0	1	0		0	0	3
PAGE DOWN	0	1	0		0	0	19
SECTION	0	0	0		0	0	5
SEARCH	1	1	0		1	0	74
SEARCH-AND	0	0	0		0	0	17
SEARCH-NOT	0	0	0		0	0	1
INDEX	0	1	1		1	1	22
ZOOM-IN	0	1	0		1	0	25
ZOOM-OUT	1	0	0		0	0	40
FILE SELECT	1	0	1		0	1	85

when the subject used the search procedure at least once during the trial. The votes were summed across the 96 trials to yield the total polls for each search procedure and converted into a proportion indicating the relative use of a search procedure for each subject. The polling procedure was used to protect against the possibility of a highly repeated search procedure (e.g., SCROLL UP, SCROLL DOWN, PAGE UP, and PAGE DOWN) biasing the strategy analysis on one trial.

The 12 search procedure proportions for novice and expert subjects were analyzed with a multivariate analysis of variance (MANOVA) to determine if there any overall search strategy differences. A MANOVA model was chosen to account for the association in the selection of individual search procedures. The results of the one-way MANOVA indicated there were no differences in the selection of search procedures by novices and experts, Wilks' $\Lambda(1,22) = 0.2741$, $\underline{p} = 0.0723$. This strategy analysis then was supplemented with a MANOVA on search procedure proportions for the slow novices (6 subjects), fast novices (6 subjects), and experts (12 subjects) since previous analyses revealed heterogeneity of novice search performance. The results of this additional strategy analysis indicated that there were differences in the selection of search procedures by slow novices, fast novices, and experts, Wilks' $\Lambda(2,21) = 0.0342$, $p = 0.0022$.

To further investigate the differences in search strategies, 12 unbalanced ANOVAs on individual search procedure proportions were conducted. The results of these ANOVAs revealed a significant difference in the selection of SCROLL UP ($F[2,21] = 4.57$, $p = 0.0225$), SCROLL DOWN ($F[2,21] = 5.85$, $p = 0.0096$), and ZOOM OUT ($F[2,21] = 11.00$, $p = 0.0005$), by slow novices, fast novices, and experts. Figure 5 shows the proportion of polls and results of Newman-Keuls procedures ($\alpha = 0.05$) for slow novices, fast novices, and experts on these three search procedures.

As illustrated in Figure 5, slow novices selected SCROLL UP, SCROLL DOWN, and ZOOM OUT procedures more frequently than fast novices and experts. The increased use of scrolling procedures by slow, inexperienced subjects replicates the results of Elkerton and Williges (1984a, 1985) and indicates that slow novices may benefit from search procedure suggestions provided by an online aid. To use Schneider's (1985) recommendation, poor or inefficient strategies should be eliminated when training a complex skill like information retrieval. Secondly, the increased use of the ZOOM OUT procedure could be an indication that slower subjects more frequently selected the wrong file and

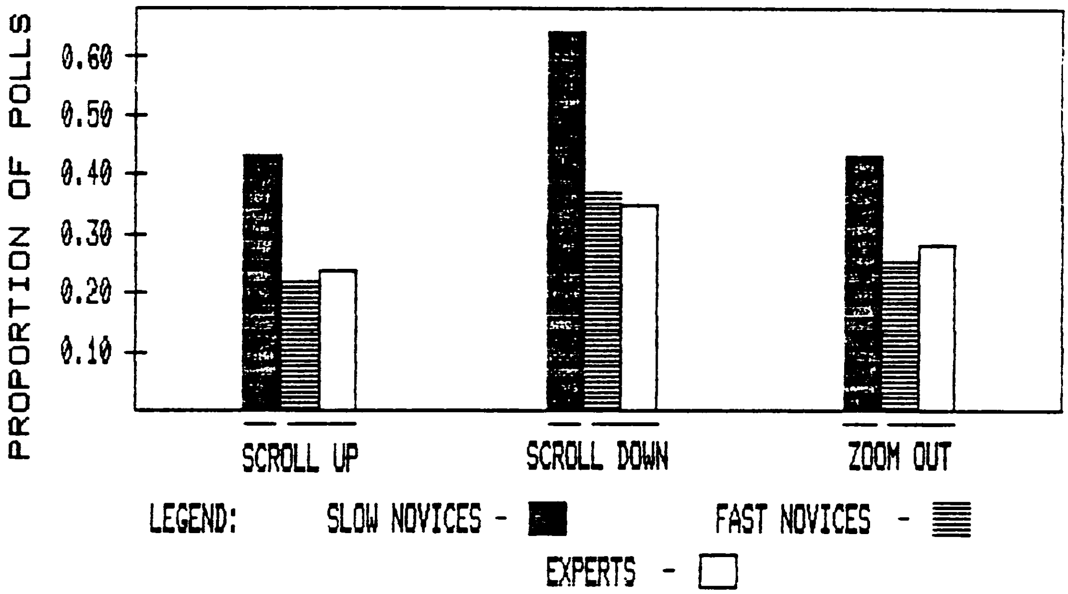


Figure 5. Significant differences in the selection of search procedures for slow novices, fast novices, and experts. Groups with a common horizontal line are not significantly different, Newman-Keuls ($\alpha = 0.05$).

had to ZOOM OUT to further search the file hierarchy. An online aid could prevent this by providing clues on the general location of a search problem in the file hierarchy.

<u>Search clusters</u>. To provide intelligent advice on the selection of search procedures requires that the task materials (search problems) be organized into a meaningful structure for users. Without this structure, command-selection aids could only offer very general advice (what search procedure to use based on all trials) or very specific advice (what search procedure to use for a particular trial). To extract the task structure, the 96 X 96 distance matrix for expert subjects was analyzed with hierarchical cluster analysis using the centroid method (Everitt, 1974). Expert subjects were focused on during cluster analysis since the performance analyses found these subjects to be a more homogeneous group than novices.

The hierarchical cluster analysis was used as a graphical technique to suggest homogeneous sets of search problems. During this analysis, the information in the search problems and the file and line locations of the search problems were used to develop the search clusters. The cluster analysis was started at 15 clusters. Although this starting point was somewhat arbitrary, a moderate number of search clusters was desired since an extreme number would impede construction of the command-selection models.

At 15 clusters there were two search problems (Items 34 and 43 in Appendix H) which formed two individual clusters. To avoid these single item clusters the analysis proceeded to 13 clusters where one of the search problems (Item 43) joined a cluster and the other (Item 34) remained as a single cluster. At this level, several reasonable search clusters were clear and are described in Table 4. Included in Table 4 are examples of representative search problems. In addition to Table 4, the dendogram in Figure 6 shows the hierarchical structure of the 12 multiple item clusters and the size of these search clusters.

A decision was made to stay at 12 clusters since moving up the dendogram would immediately join Clusters 7 and 8 (see Figure 6). Clusters 7 and 8 were not joined since these search problems contained specific information that identified the tank or APC (armored personnel carrier) equipment file where the information could be located. Joining these two sets of search problems would destroy the file-location specificity which was suggested as a desirable feature of an online aid in the search strategy analyses.

The problem of Item 34 being a singular cluster was resolved by inspection. Item 34 (Locate the vehicle with ID code 34037 that is on reserve and has 205 battle hours) was a difficult search problem that relied on subtle memory

TABLE 4

Descriptions and Examples of the 12 Search Clusters

Cluster 1 - Specific APC Inventory: Locate the BTR-60 armored personnel carrier with ID code 4AAE3 that is in the Forest regiment.

Cluster 2 - Specific Tank Inventory: Locate the PT-76 tank on reserve with the most battle hours.

Cluster 3 - Unspecified APC Inventory (Embedded): Locate the maintenance battalion of the armored carrier with an ID code of 69024.

Cluster 4 - Unspecified Tank Inventory (Embedded): Locate the battle tank with ID code 21XF.

Cluster 5 - Unspecified APC Inventory (Nonembedded): Locate the total number of armored personnel carriers in regiment number 499.

Cluster 6 - Unspecified Tank Inventory (Nonembedded): Locate the total number of battle tanks in the Renegade regiment.

Cluster 7 - Equipment for APC: Locate the height of the BMP-1 armored personnel carrier.

Cluster 8 - Equipment for Tank: Locate the method of ranging for the T-10 tank.

Cluster 9 - Combat Support Information (Subgroups): Locate the only subgroup of the anti-aircraft gun regiment.

Cluster 10 - Combat Support Information (Mission and Operations): Verify that the engineer battalion can operate a sawmill.

Cluster 11 - Army Operations (Numerical): Locate the number of enlisted personnel in the medical battalion.

Cluster 12 - Army Operations (Verbal): Verify that the tank division will conduct mobile counterattack operations.

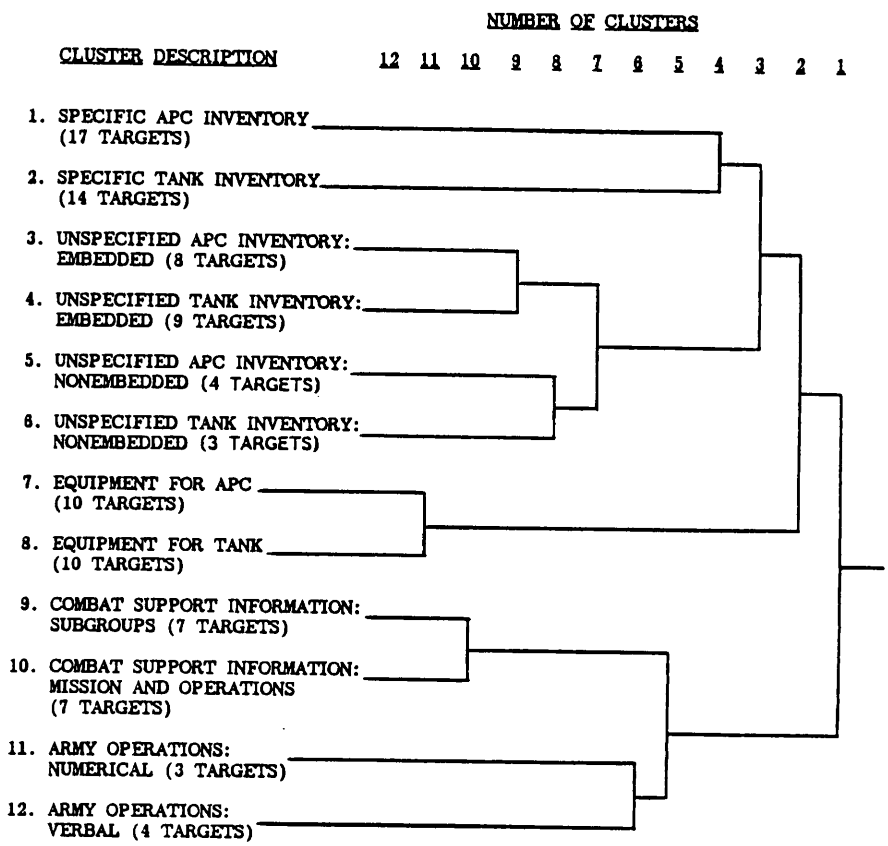


Figure 6. Dendogram of the 12 search clusters.

cues. Subjects would have to recall that ID codes with 5 places denoted an armored personnel carrier located in an inventory file. As a result, Item 34 was placed in the cluster associated with an unspecified and embedded armored personnel carrier inventory (Cluster 3). A similar memory problem was clear with Item 9 (Locate the number of vehicles in the Razor regiment). Originally, the cluster analysis placed this search problem in the cluster related to unspecified and nonembedded tank information (Cluster 6). However, the actual location of the search problem was at the top of one of the armored personnel carrier inventory files. The search problem, therefore, was shifted to Cluster 5 (Unspecified APC Inventory: Nonembedded).

Aside from these slight memory-related anomalies, the results of the sorting and cluster analysis were satisfying since the structure of the search clusters resembled the structure of the database (see Figure 1). For example, the dendogram presented in Figure 6 illustrates that experienced subjects sorted search problems into search clusters associated with inventory information (Clusters 1 - 6), search problems associated with equipment (Clusters 7 and 8), combat support search problems (Clusters 9 and 10), and search problems related to army operations (Clusters 11 and 12).

In addition, several other dimensions of the search problems emerged from the dendogram. Experts subjects in sorting the search problems made a clear distinction between specific inventory problems (Clusters 1 and 2) and unspecified inventory problems (Clusters 3 - 6). The latter class of search problems required subjects to search several inventory files. Further distinctions were made within the unspecified inventory problems with regard to the approximate location of the item in the inventory file. In all inventory files a summary table was available at the top of the file. Search problems located in the summary table were clustered together and were classified as nonembedded items (Clusters 5 and 6). In contrast, embedded search problems (Clusters 3 and 4) were located throughout the inventory files and frequently required a ballistic search movement into the body of the file for item location. External empirical support for the validity of the embedded-nonembedded dimension can be found in an earlier file search investigation by Elkerton and Williges (1984a). These investigators found significant increases in retrieval time and effort for embedded search items when compared to nonembedded items.

The last two dimensions evident in the dendogram of Figure 6 were concerned with the actual content of the combat support files and the army operations file. Information contained in the combat support files appeared to be separated with regard to subgroups (Cluster 9) and mission or operational capabilities (Cluster 10). The source of this distinction was clear when the presentation formats of subgroups and mission or operational capabilities were examined. Subgroup data in the combat support files were available in column lists, while mission or operational capabilities were presented as sentence lists. A similar distinction was drawn in the army operations file. Expert subjects appeared to separate search problems based on whether information was numerical and column formatted (Cluster 11), or verbal and sentence formatted (Cluster 12).

The 12-cluster solution presented in Figure 6 represents a model based on the sorting behavior of all expert subjects. This overall model was thought to be more appropriate than a hierarchy generated by a single expert due to the large variability in sorting behavior. The number of lower-level search groups generated by experts after the first sorting phase ranged from 3 to 33 groups with a median of 9 groups. In the second sorting phase, experts sorted the lower-level search groups into 2 to 9 higher-level groups with a median of 4 groups. This variability indicated that an individual solution had the potential of being an idiosyncratic classification of the search problems.

Empirical support for the 12 search clusters can be found both in the search performance and search strategy data. However, analysis of this data was not straightforward since the search clusters were determined after collecting the information retrieval data. As a result, the number of items in each search cluster could not be controlled. To overcome this limitation, the means of the dependent measures for each search cluster and subject were computed and analyzed in a balanced ANOVA.

Two-way ANOVAs were conducted to determine the effect of search cluster on search performance for both expert and novice subjects. The results of the ANOVAs revealed highly significant effects of search clusters for total operations ($F[11,242] = 11.72$, $p = 0.0001$), different operations ($F[11,242] = 16.31$, $p = 0.0001$), total time ($F[11,242] = 5.65$, $p = 0.0001$), and total movement ($F[11,242] = 11.06$, $p = 0.0001$). Correlation ratios, η^2, (Thorndike, 1978) were calculated and indicated that search cluster could describe 24.1%, 29.2%, 14.4%, and 25.3% of the search variance for the averages of total operations, different operations, total time, and total movement, respectively. These search cluster effects demonstrate that the type of target influenced a subject's search performance. Moreover, the lack of any significant ($p < 0.05$) subject experience by search cluster interaction indicates that the performance of novice and expert subjects was not influenced differentially by search clusters. Further unbalanced ANOVAs that split novices into fast and slow groups yielded similar conclusions.

Table 5 displays the search performance means for each search cluster in decreasing order. Included in Table 5 are the results of a Newman-Keuls analysis ($\alpha = 0.05$) on the means of the 12 search clusters for each search performance measure. Inspection of the results displayed in Table 5 suggests that the search problems in Clusters 3, 5, and 6 were consistently more difficult to find. These search problems were unspecified inventory items that required a large amount of file hierarchy traversal. Table 5 also shows that Clusters 1, 2, 7, 8, and 11 were found consistently faster and more efficiently than other types of search problems. These items usually contained numerical and statistical data in specific files. The results in Table 5 suggest that the search clusters were not highly differentiated in terms of search performance. However, the lack of differentiation was expected. Search operations, time, and movement are important file search variables, but

TABLE 5

Effects of Search Clusters on Average Search Performance

Total Operations Mean	Cluster #	Different Operations Mean	Cluster #	Total Time Mean	Cluster #	Total Movement Mean	Cluster #
17.8	6	5.2	6	117.88	6	277.4	5
17.4	5	4.8	5	114.73	3	201.8	6
15.0	3	4.8	3	108.30	9	194.1	3
10.5	4	4.0	9	108.13	5	121.0	4
9.8	12	4.0	10	106.64	12	101.5	9
9.8	9	3.9	4	88.64	10	95.5	11
9.1	10	3.7	7	81.23	11	92.3	12
8.3	7	3.5	12	73.72	4	88.6	10
7.4	11	3.4	8	72.76	7	76.5	7
6.8	8	3.2	1	62.24	1	56.4	1
5.8	1	3.1	11	54.71	8	45.1	2
5.0	2	3.1	2	48.81	2	35.0	8

Cluster 1: Specific APC Inventory.
Cluster 2: Specific Tank Inventory.
Cluster 3: Unspecified APC Inventory (Embedded).
Cluster 4: Unspecified Tank Inventory (Embedded).
Cluster 5: Unspecified APC Inventory (Nonembedded).
Cluster 6: Unspecified Tank Inventory (Nonembedded).
Cluster 7: Equipment for APC.
Cluster 8: Equipment for Tank.
Cluster 9: Combat Support Information (Subgroups).
Cluster 10: Combat Support Information (Mission and Operations).
Cluster 11: Army Operations (Numerical).
Cluster 12: Army Operations (Verbal).

Means with a common vertical line are not significantly different, Newman-Keuls ($\alpha = 0.05$).

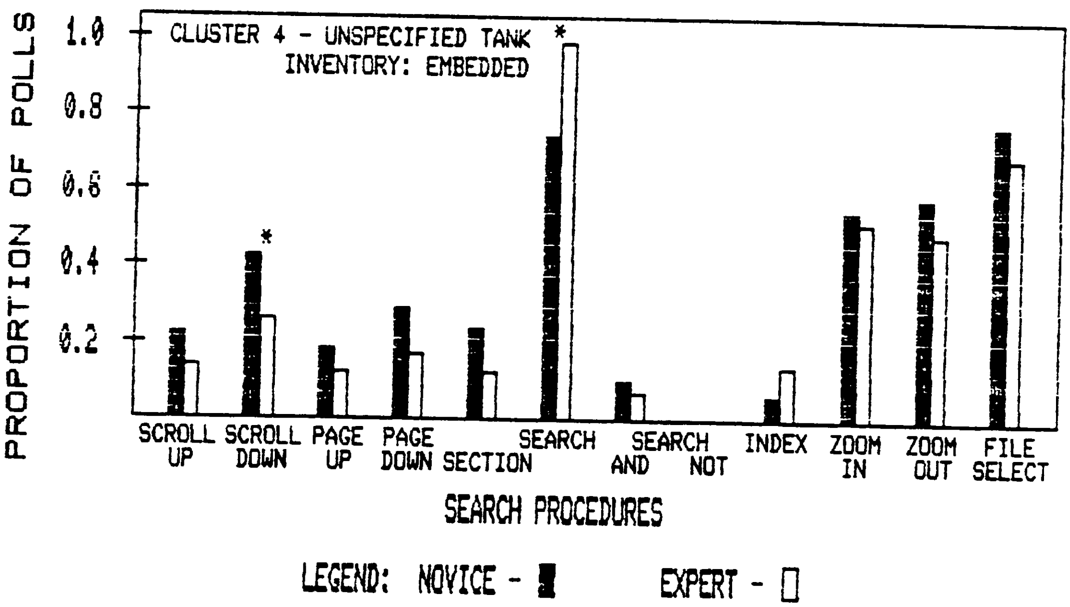
are only surface indicators of the cognitive processes required for information retrieval.

Support for the search clusters also was found when analyzing search strategy for different types of search problems. A three-way, mixed-factor ANOVA was conducted on subject experience, search procedure, and search cluster to determine whether novice and expert subjects used different search strategies for the search clusters. Subject experience was the only between-subjects variable in this ANOVA with search cluster and search procedure serving as within-subjects variables. As in previous search strategy analyses, the proportion of search procedure use was assessed with a polling procedure to prevent the possible bias of a highly repeated search procedure on a single trial.

Three statistical interactions were of interest in the three-way ANOVA. The search procedure by subject experience interaction was tested to check the MANOVA results on search strategy for experts and novices. Consistent with the conclusions of the MANOVA, expert and novice subjects did not select different search procedures overall ($\underline{F}[11,242] = 0.73$, $\underline{p} > 0.05$). However, the significant interactions of search cluster by search procedure ($\underline{F}[121,2662] = 12.87$, $\underline{p} = 0.0001$) and search cluster by search procedure by subject experience ($F[121,2662] = 1.58$, $p = 0.0001$) suggest that search cluster influenced the selection of search procedures by expert and novice subjects.

Although the large number of degrees of freedom in these tests resulted in a sensitive analysis, these results were informative for two reasons. First, search clusters were identified as an important determiner of search strategies. Second, the search strategies of expert and novice subjects were found to differ when search cluster was considered. The influence of both interactions can be seen in the search strategies of novice and expert subjects displayed in Figure 7 for Cluster 4 (Unspecified Tank Inventory: Embedded) and Cluster 9 (Combat Support Information: Subgroups). Included in each histogram are asterisks which indicated whether a Fisher's LSD (least significant difference) test was significant ($\alpha = 0.05$) when comparing novice and expert search proportions on a specific search cluster. Fisher's LSD test was used only to suggest search strategy differences in this complex three-way interaction.

Examination of Figure 7 revealed large differences in the selection of the search procedures between the two search clusters. The profiles of the two histograms are markedly different. Cluster 4, an unspecified and embedded tank



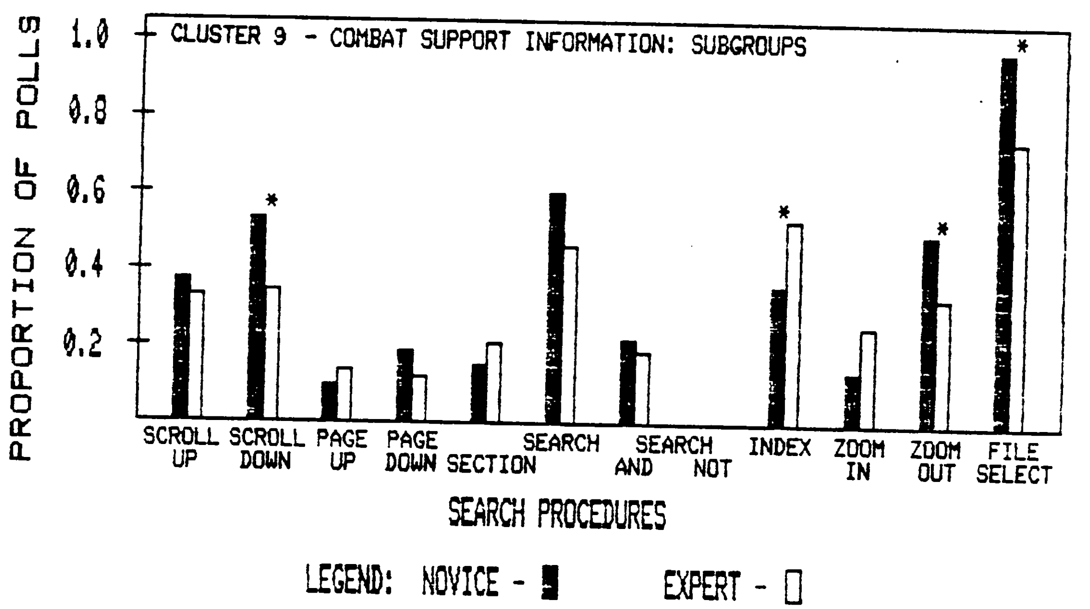


Figure 7. Search strategies of novice and expert subjects for Clusters 4 and 9. Asterisks indicate significant differences, Fisher's LSD ($\alpha = 0.05$), between the selection proportions of experts and novices.

inventory cluster, required subjects to search the tank inventory files systematically. Experts in Cluster 4 selected the SEARCH command more frequently than novices, while novices used the SCROLL DOWN procedure to a greater extent. In contrast to Cluster 4, Cluster 9 required subjects to search the two combat support files for subgroup information. In searching these two files, experts used fewer FILE SELECT and ZOOM OUT commands and more INDEX commands than novices. Novices apparently failed to exploit the additional information in the INDEX procedure and as a result used the SCROLL DOWN more often than experts. Finally, there was a large decrease in use of the SEARCH procedure for expert subjects from Cluster 4 to Cluster 9 (Fisher's LSD, $\alpha = 0.05$). Experts apparently realized that the SEARCH procedure was not the only ballistic procedure to locate information in the combat support files.

These are only a few of the comparisons that can be made when analyzing search strategy at the cluster level. The point was not to be exhaustive in the post hoc analysis but to determine whether search strategy analysis was beneficial at this level. Indeed, two major conclusions were drawn from the analysis of search clusters. First, the 12 search clusters were useful in describing the class and general location of information in the database. Second, the 12 search clusters influenced search performance, and to a greater extent, search strategy. Together these two conclusions indicate that component search tasks, in the form of search clusters, can be identified through structured sorting procedures. The next required step was to extract strategy information from these component search tasks so that an online aid can assist novices on specific search clusters. More specifically, the online aid should emphasize meaningful and consistent components of the file selection and search task to develop the information retrieval skills of inexperienced users (Schneider, 1985).

Constructing Command-Selection Models

Given the search performance and search strategy differences between novice and expert subjects, the development of frequency, sequence, and plan-based models of command selection was based on the behavior of expert subjects. As compared to novices, experts were a more homogeneous group of subjects and were capable of generating a task structure for providing intelligent advice about information retrieval. With this framework, the next three sections give the methodological details surrounding the construction of the three command-selection models.

Frequency model development. Generating the frequency-based model for command selection closely paralleled the procedures described by Elkerton and Williges (1985). Briefly, the frequency-based model was based on the overall selection of search procedures by expert subjects. A polling procedure similar to that diagrammed in Table 3 for analyzing search strategies was used for determining the most frequently used search procedures. The difference between the polling procedure in Table 3 and the polling procedure for the frequency-based model was in terms of summing the polls. Table 6 illustrates these changes in the polling procedure for a specific search problem (Item 26) in Cluster 9 (Combat Support Information: Subgroups).

As shown in Table 6, summing the polls occurred at two stages. The first stage summed the 12-vote vectors of each subject for a specific search problem (Item 26). The result of this summation was an item profile indicating what search procedures were used most frequently by expert subjects for a search problem. The second summation in Table 6 shows that individual item profiles were summed to yield an overall cluster profile. The cluster profile indicates the selection frequency for specific search procedures on a set of search problems. For example, the most frequently selected search procedures for Cluster 9 were FILE SELECT,

TABLE 6

Polling Procedures and Frequency Profiles for Cluster 9

SEARCH PROCEDURES	EXPERIENCED SUBJECTS 1	2	3	. . .	11	12	ITEM PROFILE
SCROLL UP	0	0	0		1	1	4
SCROLL DOWN	0	0	0		1	0	5
PAGE UP	0	0	0		0	0	2
PAGE DOWN	0	0	0		0	0	1
SECTION	0	0	0		1	0	2
SEARCH	1	0	0		1	0	6
SEARCH-AND	0	0	0		0	0	2
SEARCH-NOT	0	0	0		0	0	0
INDEX	0	1	1		1	1	7
ZOOM-IN	1	0	0		1	0	3
ZOOM-OUT	1	1	1		0	0	5
FILE SELECT	1	1	1		0	1	8

SEARCH PROCEDURES	ITEMS IN CLUSTER 1	2	3	. . .	6	7	CLUSTER PROFILE
SCROLL UP	4	3	4		7	4	28
SCROLL DOWN	5	1	6		6	6	30
PAGE UP	2	1	2		2	1	12
PAGE DOWN	1	1	2		2	0	10
SECTION	2	3	1		4	3	18
SEARCH	6	4	4		9	6	39
SEARCH-AND	2	3	3		2	2	16
SEARCH-NOT	0	0	0		0	0	0
INDEX	7	6	7		5	8	47
ZOOM-IN	3	3	3		1	5	23
ZOOM-OUT	5	3	5		4	3	29
FILE SELECT	8	9	9		11	7	63

followed by INDEX, SEARCH, and SCROLL DOWN. The other 11 cluster profiles for the frequency-based model are presented in Appendix K.

The relationship between the cluster profiles of experts and the type of information in the search problem was critical to the success of this performance-based approach. However, inspection of the example provided in Table 6 (as well as other cluster profiles in Appendix K) suggested a high degree of correspondence between profiles and type of cluster. For instance, the FILE SELECT procedure is efficient since the search problems are contained in the combat support files. Likewise, the INDEX and SEARCH procedures would be useful since these procedures could quickly access the subgroup information in the file. In fact, novices could benefit from a suggestion to use INDEX since the data in Figure 7 indicated that novices may not fully utilize this procedure.

How might this frequency-based information on the command selection of expert subjects be used? First, the most frequently selected search procedures may be used to compare novice and expert command selection. If a novice chooses an infrequently selected search procedure, then an online aid could use the cluster profiles to base a decision on whether advice or training should be given. In addition, if the online aid decides to give advice, the more frequently selected search procedures could be suggested for use. Thus, the cluster profiles could serve both as a diagnostic and as a remedial device in an online command-selection aid.

Sequence model development. One obvious limitation of the frequency-based model was the lack of command-sequence information. Novice subjects may need to know what search command to use after another. To extract this information, second-order transition matrices were constructed to capture the sequence of command use. Table 7 shows a second-order transition matrix that was constructed for Cluster 9 (Combat Support Information: Subgroups). In Table 7 the search procedure before the transition appears as a row entry and the search procedure after the transition appears as a column entry. In addition, Table 7 contains an initial profile that was used to describe the first search procedure used by experts. All of the entries in Table 7 are total polls summed across subjects and search problems.

The construction of the transition matrices and initial profiles was based on polling procedures similar to those used in the frequency-based models. Each subject on every trial was given a 12 X 12 matrix of 144 votes corresponding to the 144 possible search command transitions. If a subject moved from one search procedure to another during

TABLE 7

Transition Matrix and Initial Profile for Cluster 9

From	To 1	2	3	4	5	6	7	8	9	10	11	12	Initial Search Profile
1	20	10	1	0	0	3	0	0	0	16	1	3	0
2	10	22	3	0	0	2	1	0	0	0	2	0	0
3	1	2	2	3	1	0	0	0	0	6	2	1	0
4	0	1	4	2	2	2	0	0	1	1	1	0	1
5	1	0	0	2	2	3	0	0	4	1	3	4	4
6	14	13	1	1	1	6	3	0	2	0	7	6	13
7	0	6	0	0	0	3	16	0	0	0	1	2	3
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	8	5	5	2	3	2	0	0	2	0	13	5	16
10	0	1	0	4	0	12	4	0	3	0	2	0	1
11	0	0	2	0	3	1	0	0	2	1	0	23	0
12	0	4	0	0	11	16	7	0	31	0	3	0	46

Search Procedures:

1. SCROLL UP
2. SCROLL DOWN
3. PAGE UP
4. PAGE DOWN
5. SECTION
6. SEARCH
7. SEARCH-AND
8. SEARCH-AND-NOT
9. INDEX
10. ZOOM IN
11. ZOOM OUT
12. FILE SELECT

the trial, then the appropriate cell in the matrix would be given a value of 1, otherwise, the cell would have a value of 0. Individual transition matrices for each subject were then summed to yield a transition matrix for a search problem. These search problem matrices were then summed to yield a cluster transition matrix. The initial profiles, in contrast, were easier to construct since each subject contributed one poll to the initial profile for each search problem.

Inspection of the transition matrix and initial search profile in Table 7 provides a wealth of information that could be valuable to novices. For example, expert subjects used FILE SELECT frequently as the first search operation. After this initial FILE SELECT procedure, expert subjects frequently selected the INDEX procedure. Thus, when compared to the frequency model, the sequence model would provide similar information in suggesting the use of FILE SELECT and INDEX. However, command-sequence information may be useful to novices and will describe other situations that are not recorded with the frequency models. In the transition matrix in Table 7 for example, there were a large number of transitions from ZOOM OUT to FILE SELECT. This file traversal behavior was characteristic of Cluster 9 (Combat Support Information: Subgroups) since subjects may have to check both combat support files to locate a specific subgroup. These and other interesting transitions make the sequence model an attractive representation for an online aid. Further information on all transition matrices and initial profiles for the 12 clusters are available in Appendix L.

When implemented, the sequence model was to suggest the most frequently selected search procedures to novices based on the previous command. Conceptually, once a previous search command was identified, the row of the transition matrix served as the frequency profile from which advice could be given. For instance, if the search problem was part of Cluster 9 and the novice had previously selected FILE SELECT, then Row 12 in Table 7 would serve as the basis for command selection advice at that point in retrieval.

<u>Planning model development</u>. Construction of the plan-based model attempted to simplify the command-sequence information, but expanded on the conditions and situations for using a search procedure. A single sequence of search procedures was needed that contained both a strategic and a search cluster component. Ideally, an annotated search plan was desired which could guide a novice user effectively through the database with a small number of search procedures.

Several sources of data were used to construct the search plans for each search cluster. Figure 8 shows both the data and the process for search plan construction. The first step in the process was to identify search plans that were reported verbally by experts in sorting the search problems. Analysis of these verbal reports were by far the most subjective procedure employed in the search plan analysis since the reports were often fragmentary or difficult to understand. However, the verbal reports did provide the experimenter with useful hypotheses about candidate search strategies that were verified with more objective measures. For example, with Cluster 9 (Combat Support Information: Subgroups) experts reported using FILE SELECT to position to the combat support files, then using INDEX, SEARCH, or SECTION to locate subgroup data.

The next step of the search plan analysis consisted of identifying the second-order search transitions that corresponded to these verbal reports. In this specific cluster, empirical support was sought for the FILE SELECT to INDEX, the FILE SELECT to SEARCH, and the FILE SELECT to SECTION transitions. Examination of Table 7 shows that these transitions were frequently observed for search problems in Cluster 9 (Combat Support Information: Subgroups). However, the number of transitions from FILE

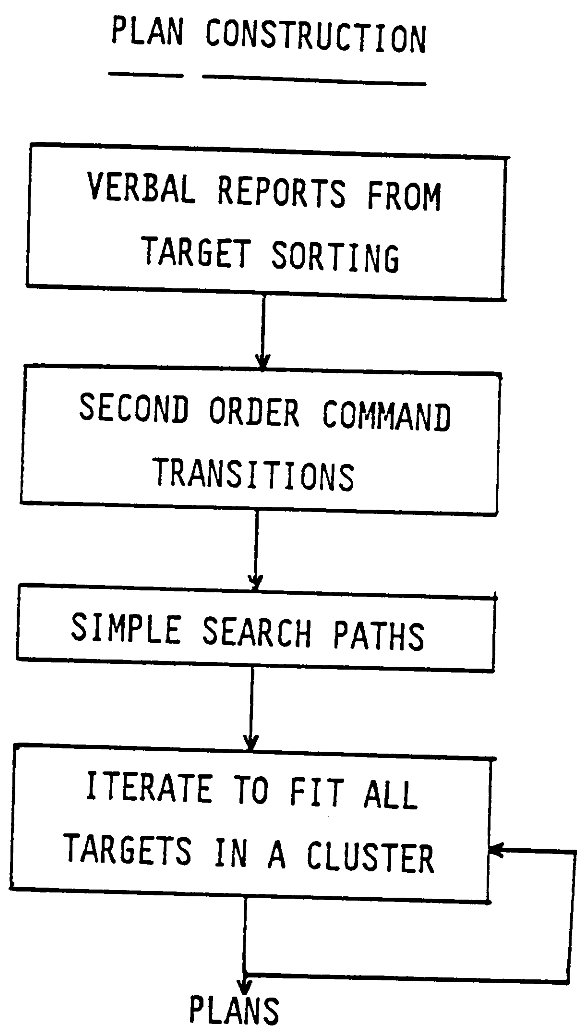


Figure 8. Processes for search plan construction.

SELECT to INDEX was twice the number of transitions observed from FILE SELECT to SEARCH, and FILE SELECT to SECTION. As a direct result, the search plan analysis focused on the FILE SELECT to INDEX search sequence.

The third step was to supplement, if possible, the second-order transition information with longer sequences of search procedures. For example, in Cluster 9 simple search paths were constructed with path algebra (Alty, 1984) that included the FILE SELECT to INDEX transition. A simple search path is a sequence of two search procedures or more where the same procedure cannot be used twice. Using these simple search paths, frequently used sequences of search procedures were identified that contained the second-order transitions under investigation. In this example, experts frequently selected ZOOM OUT either before (45.2%) or after (32.3%) the transition from FILE SELECT to INDEX. Clearly, ZOOM OUT was associated closely with the FILE SELECT to INDEX transition and was marked for further analysis.

The final step of the search plan construction diagrammed in Figure 8 was iterative. The sequence of search procedures were assembled in orders that could be used to guide a novice user to the information contained in a search cluster. For the information in Cluster 9 (Combat Support Information: Subgroups), the sequence: FILE SELECT, INDEX, and ZOOM OUT was identified as a reasonable search plan for finding the information. Verbal explanations were then written to supplement the search plan. The explanations attempted to provide information on how to use the specific search procedures to retrieve data contained in the search cluster. The explanation could include information on the general location of the search problem in the database, the keywords to look for in files, and other procedural directions such as when to repeat steps of search plan. Information for the explanation was drawn from the verbal reports, the search cluster descriptions, and the actual search problems. Next, the search plans were refined iteratively in an attempt to provide good advice for all problems in a search cluster. Changes that could occur to the search plans during iteration included changes in the wording, and adding a search procedure to improve the coverage for the set of search problems.

The final search plan for Cluster 9 (Combat Support Information: Subgroups) is displayed in Table 8. In addition, the other search plans generated for the other 11 search clusters are available in Appendix M. As can be seen in Table 8, the search plan contains both a sequence of search procedures and a explanation for using the procedures. The decision was made to include ZOOM OUT as a

TABLE 8

Final Search Plan for Cluster 9

Steps	Description
1.	FILE SELECT (to a combat support file)
2.	INDEX (to locate subgroup information)
3.	If target is not located ZOOM OUT (and repeat steps 1 and 2)

conditional step since novices might not know which combat support file to look in. Comparing this planning model with the previous performance models (frequency and sequence) illustrates the additional information that is available on general location of the search problems, and the general type of information to be searched for. In essence, the goal of the planning model was to make explicit the component search tasks that were identified by experts.

Summary

Four major results were obtained in Experiment 1. The first two results focused on the differences between expert and novice users. Of primary importance was the demonstration of overall differences in the search performance of expert and novice users. Demonstrating this difference was required before an online aid could implemented and evaluated. The second and somewhat surprising result was the heterogeneity of novice search performance that contributed to the performance differences and obscured the strategy differences between novices and experts. The implication was that novices could be viewed in future evaluations as two groups of subjects: fast and slow novices. The theoretical justification rests on data surrounding the acquisition of high-performance skills

(Schneider, 1985). This research predicts large differences in the skills of new users of complex systems.

The last two results centered on the development of methods to alleviate these differences through online command-selection aids. Specifically, a component task model was developed using the sorting and clustering procedures that identified 12 sets of homogeneous search problems. These 12 search clusters were found to be useful in describing the more cognitive aspects of information retrieval. Most importantly in this experiment, three command-selection models were described and constructed that could be used for providing novice users different types of assistance or instruction in the information retrieval task.

EXPERIMENT 2: EVALUATION OF THE COMMAND-SELECTION AIDS

Approach

The differences between novices and experts in the information retrieval task suggests that providing novice users an online aid may be beneficial. As was stated in the previous experiment, two potential benefits could result from effective aiding. First, slower novices that are provided an online aid could improve their information retrieval skills. Second, aiding could result in a more homogeneous group of novice users that would be easier to support. These are extremely important goals since the differences between slow novices and other subjects were large and persisted over several days. Slow novices were not capable of closing the "skill gap" between themselves and other more proficient users.

Unfortunately, novice heterogeneity could pose problems for an online aid. Novices in this task have a wide variety of needs that have to be satisfied. Some novices may require a large amount of detail in selecting commands, while others might only need hints. The three different command-selection models were constructed to answer this question. Progressing from the frequency to the sequence to the plan-based model adds more information to the command-selection aid. In this experiment the question was asked: What type of command-selection information is needed by the novice user?

Similarly, novice heterogeneity may pose problems in defining a human-computer dialogue for an online aid. Slow and inefficient novice users may be unaware of their computing shortcomings. These types of users may require computer-initiated advice to call attention to their problems. Fast and efficient novice users, however, may not require and may even be slowed by computer-initiated advice. These fast novices probably have an accurate understanding of their skills and will benefit from advice on only rare occasions. Thus, a dialogue that is more user controlled (user- or mixed-initiated) may be more helpful and less intrusive to these faster novices.

To evaluate these issues an experiment was conducted using novice subjects that received various combinations of command-selection aids (frequency, sequence, and plan-based models) and dialogue initiatives (computer, user, and mixed). The approach was to determine the effectiveness of the three command-selection aids with the three dialogue initiatives. Effectiveness was to be assessed through comparison of aided novices with the novice and expert groups of Experiment 1. Both aided and unaided search performance and search strategy were to be evaluated in this experiment. The goal of this approach was to determine which online aids were effective in assisting users in the information retrieval task, as well as which online aids resulted in the most learning. Finally, all novice subjects in this experiment were asked to evaluate the command-selection aids subjectively. In online advisory systems, user satisfaction is of major importance since the perceived quality of the advice could affect user interaction with the aid.

Method

Subjects. An additional 43 novices volunteered for the experiment. The procedures and criteria for the subjects were the same as Experiment 1. Only one novice subject in this experiment was excluded for failure to find the training information fast enough (under 300 seconds, average). Another 6 novice subjects were used as pretest subjects resulting in a sample size of 36 novices for the experiment.

Experimental design. Table 9 shows the design of Experiment 2. The factorial experiment was a 3 X 3 mixed-factor design with command-selection model as the between-subjects variable and dialogue initiative as the within-subjects variable. Table 9 also shows that the novices and experts from Experiment 1 served as control groups for the command-selection aids evaluated in Experiment 2. Therefore, to facilitate comparisons with the control novices and experts, all procedures and materials in Experiment 2 were the same as Experiment 1 with exception of the online aiding manipulations.

Each of the 36 novice subjects in Experiment 2 was assigned randomly to one of three command-selection aids shown in Table 9. After receiving two initial training sessions on the information retrieval task, all aided novices could receive command-selection advice through the three different dialogue initiatives on three separate sessions. Before the start of each experimental session, all 36 novices received instructions both on the type of information presented by the online aid (Appendix N) and the procedures for accessing the command-selection advice (Appendix O). In these instructions subjects were encouraged to use the online aid, but were told that speed of information retrieval was still important.

TABLE 9

Experimental Design

Aided Novices (Experiment 2)			
	Dialogue Initiative		
Command-Selection Model	User	Computer	Mixed
Frequency		Subjects 25 - 36	
Sequence		Subjects 37 - 48	
Plans		Subjects 49 - 60	
Control Groups (Experiment 1)			
Novices		Subjects 1 - 12	
Experts		Subjects 13 - 24	

There were two reasons for selecting dialogue-initiative as a within-subjects variable given the potential for learning and transfer effects. First, the experiment was infeasible to conduct with dialogue initiative as a between-subjects variable due to the length of data collection (5 - 6 days). Second, changing the dialogue initiative has been suggested as a method for adapting the interface to the user (Maskery, 1984). For example, a computer-initiated dialogue could change to a user-initiated or a mixed-initiated dialogue as the user becomes more proficient with the interface. To further study these sequence effects, the presentation orders of the dialogue initiatives were completely counterbalanced and are shown in Table 10. Two novices from each command-selection group were assigned randomly to these presentation orders.

Table 10 also illustrates that aided novices received a final unaided transfer session after completing the three dialogues. The goal of this final session was to assess the training effectiveness of the three command-selection aids. Therefore, in addition to evaluating the ability of the command-selection aids to assist novices on the current retrieval task, the experiment was also a transfer of training design.

TABLE 10

Presentation Orders of the Dialogue Initiatives

Presentation Order	Session 3	Session 4	Session 5	Session 6
CMU	Computer	Mixed	User	Unaided
CUM	Computer	User	Mixed	Unaided
MCU	Mixed	Computer	User	Unaided
MUC	Mixed	User	Computer	Unaided
UCM	User	Computer	Mixed	Unaided
UMC	User	Mixed	Computer	Unaided

Implementing the command-selection models. Implementing the frequency, sequence, and plan-based models to provide advice to novice users required that the search cluster be identified, the command-selection information in Appendices K, L, and M be presented visually, and decisions be made about how novices should be monitored and when advice should be given. The first problem was trivial, while the later two problems were significant issues that were addressed when implementing each command-selection model.

Decisions on how the frequency command-selection model was implemented were based largely on the results of Elkerton (1984). The results of this study indicated that a frequency profile of command use may be helpful when implemented as a ranked set of suggested search procedures on the touch keypad. The results also indicated that the number of search procedures used to determine when the novice needed advice was critical to the success the online aid. Specifically, Elkerton (1984) found that a smaller number of frequently selected search procedures (2, 3, and 4) should be used to determine when novices needed advice since a larger number (5) would result in advice being presented late in the search trial. In other words, a strict criterion for the search procedures that can be selected by novices should be used for frequency-based advice to be presented at the start of the search trial.

Although the results of Elkerton (1984) were difficult to generalize to the more complex file selection and search task, the method of providing a ranked set of highlighted search procedures on the touch keypad was followed. Furthermore, the suggested strict criterion for comparing the selection of search procedures by novices and experts was heeded for conditions where the computer would provide frequency-based advice. An initial setting of 3 was pretested and adopted as the number of frequently selected search procedures that were accepted and presented by the online aid for a specific search cluster. This criterion allowed novices to traverse the file hierarchy and to use ballistic search procedures without receiving these search procedures as advice. Overall selection frequencies were used to break ties when extracting the frequently selected search procedures from the cluster profiles in Appendix K.

An example of the frequency-based advice for the search problems in Cluster 9 is presented in Figure 9. In addition to ranking search procedures that were selected frequently by experts, the online aid also highlighted these search procedures on the touch keypad. Novices could use this advice or choose any other search procedure. Advice for the frequency model could be presented only once and would remain on the primary display until completion of the trial.

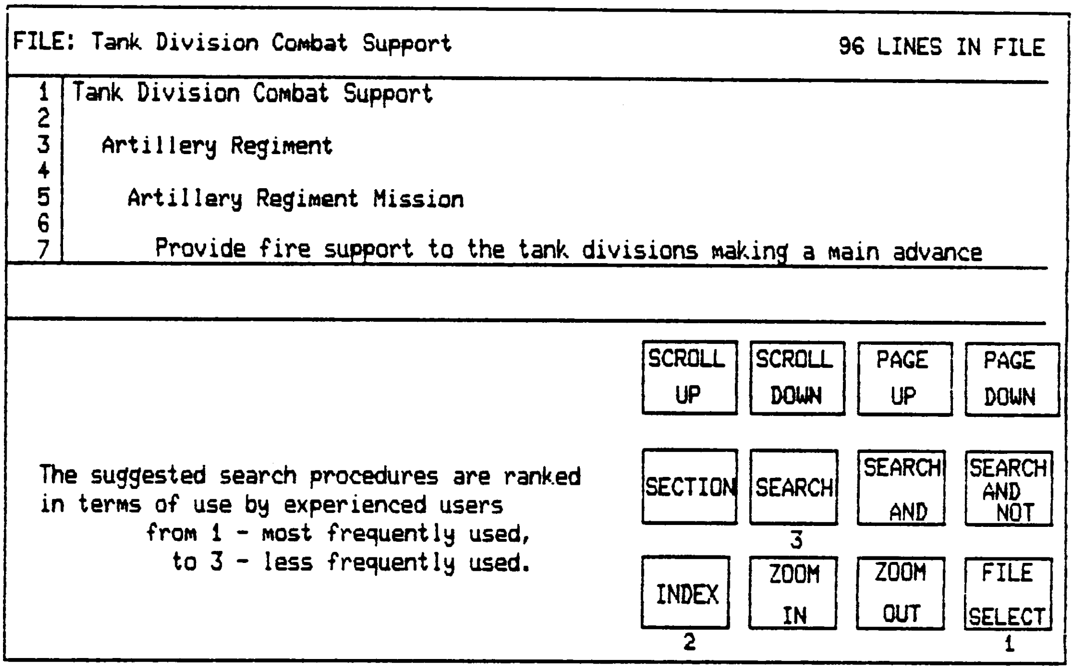


Figure 9. Frequency-based advice presented to novice subjects for search problems in Cluster 9.

The implementation of the sequence model for command-selection advice closely paralleled the frequency model in the number of presented and accepted search procedures. As an example, Figure 10 shows the command-sequence advice given to a novice after using FILE SELECT as the initial search procedure to locate information in Cluster 9 (Combat Support Information: Subgroups). Instead of offering search procedures that were used most frequently overall, the sequence model suggested search procedures that were selected frequently after the use of FILE SELECT (i.e., INDEX, SEARCH, and SECTION). These suggested search procedures were extracted from the last row of the transition matrix shown in Table 7 and represent the search procedures that experts used most frequently after the selection of FILE SELECT. Similar to the frequency model, ties were broken in the 12 X 12 matrices and initial search profiles (Appendix L) with an overall transition matrix and initial profile based on all clusters. Novices could choose whether to use the advice or not. However, unlike the frequency advice, command-sequence advice could be presented several times during a trial. For example, novices could receive advice at the start of the trial based on the initial search profile and then could receive further command-selection advice based on the 12 X 12 transition matrix.

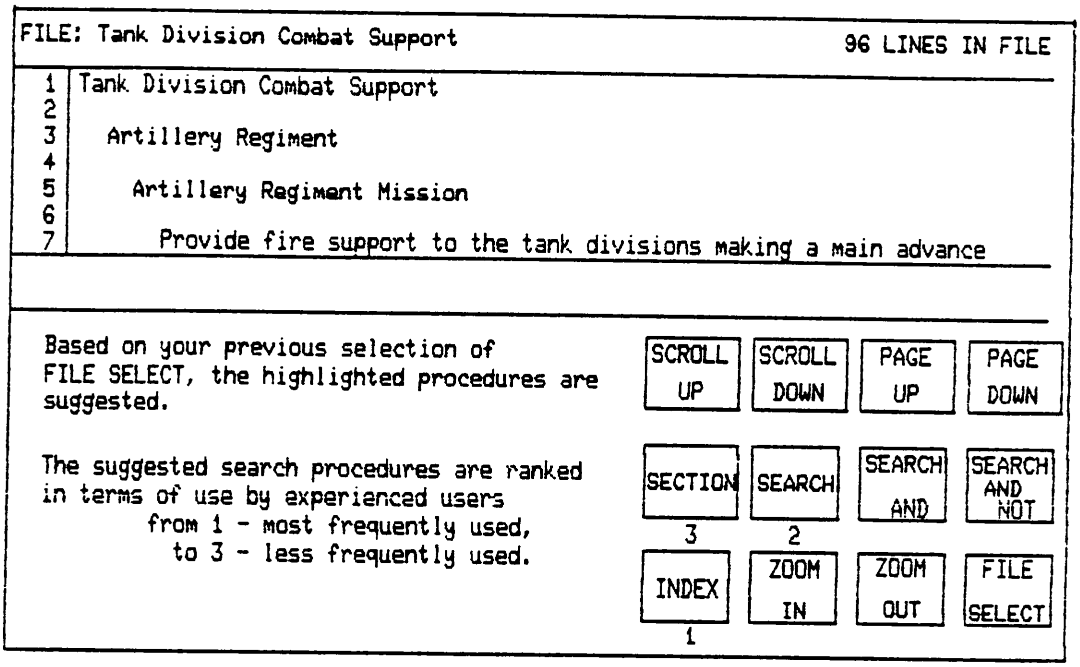


Figure 10. Command-sequence advice presented to novice subjects for search problems in Cluster 9.

The implementation of the plan-based model is shown in Figure 11. As can be seen in Figure 11, the search plan developed for Cluster 9 was presented in the work area of the primary display. Contained in this plan was a sequence of search procedures (steps) with appropriate verbal explanations. The search procedures in the plan were capitalized and highlighted. Moreover, the appropriate search procedures on the touch keypad were highlighted and numbered according to the step in the plan. All plans could be presented only once and would remain on the primary display until the end of the trial. If the work area was required by another search procedure (e.g., FILE SELECT), the planning steps were erased and automatically displayed again after completion of the search procedure.

<u>Implementing the dialogue initiatives</u>. Closely associated with the command-selection models were the implementations of the user-, computer-, and mixed-initiative dialogues. Each of these dialogues provided a different method for accessing the command-selection advice.

The design of user-initiated advice was straightforward with the frequency and plan-based models. Novices were allowed in these conditions to press a HELP function key on the VT100 keyboard at any time during the search trial to

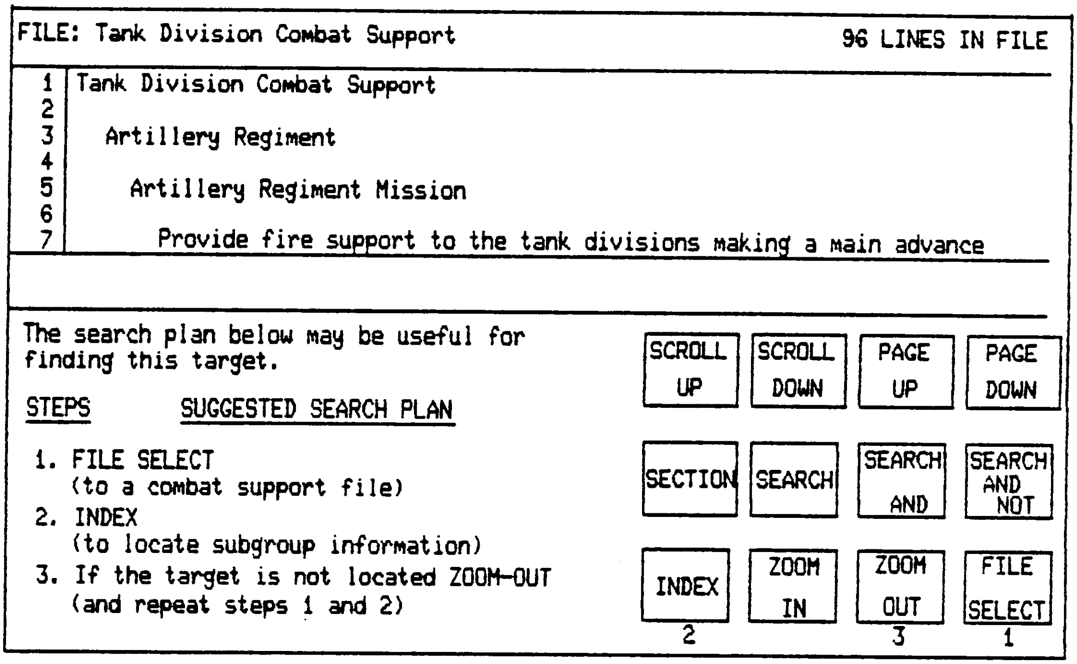


Figure 11. Plan-based advice presented to novice subjects for search problems in Cluster 9.

receive either the frequency or the plan-based advice. For the sequence model the question was asked whether novices should be allowed to press HELP more than once a trial. The decision was made to implement this capability since a possible strength of the sequence model was to provide command-selection advice at any point during search.

The design of the computer-initiated advice was more complicated for all command-selection aids. Indeed, the topics of how novices should be monitored and when command-selection advice should be given were covered briefly with the implementation of frequency-based models. To expand on this discussion, the cluster profiles of experts (Appendix K) served as a differential model (Burton and Brown, 1982) for comparing expert and novice search procedure selection. Command-selection advice was given if a novice subject used any search procedure other than the top three search procedures selected by experts. This procedure was very similar to the computer-initiated techniques employed by Elkerton (1984). However, instead of the individual search problem profiles used by Elkerton (1984), this research used the more general cluster profiles.

Providing computer-initiated advice with the sequence and plan-based models required that the selection of search procedures be monitored in terms of command-sequence rather than frequency. To accomplish this goal, the command-selection aids used the 12 X 12 transition matrix and the initial search profile for a specific search cluster (Appendix L) as the differential model to compare expert and novice search procedure selection. Similar to the frequency model, a strict criterion of the three most frequently selected search procedures was used to determine when to give command-selection advice.

For example, if the novice was searching for information represented by the initial search profile in Table 7 (Combat Support Information: Subgroups), then the three acceptable search procedures would be FILE SELECT, INDEX, and SEARCH. Choosing any other search procedure initially would lead to computer-initiated presentation of either the sequence or plan-based advice. If plan-based information was presented, then additional command-selection advice could not be given. However, if the sequence model was used, then additional command-sequence advice could be presented to the novice.

With the sequence model, if the novice took the highlighted advice and used FILE SELECT to position to another file, then the three most frequently selected search procedures in row 12 of the transition matrix in Table 7 would be used to judge the selection of the next search procedure. As seen in row 12 of the transition matrix, the novice would receive command-selection advice only when using search procedures other than INDEX, SEARCH, and SECTION. This technique of comparing the search procedure selection of novice users based on the previously selected command would continue until the end of the trial.

In pretesting, however, computer-initiated advice with the sequence model was disastrous. The command-selection advice was presented too frequently since the sequence model could provide advice at every step in the search trial. Novices would become overwhelmed with the amount of advice. To prevent this information overload, computer-initiated advice with the sequence model was constrained to provide advice only when the novice entered a new file in the hierarchy.

The final dialogue was a mixture of computer- and user-initiated dialogues that attempted to maintain user control. In this mixed-initiative dialogue, novices could request command-selection advice by pressing the HELP function key on the VT100 keyboard. In addition, the command-selection aid would monitor the use of search procedures with the computer-initiated techniques just described and would suggest to the novice that command-selection advice was available. Suggesting the availability of advice was implemented by presenting the highlighted message "If you want advice press HELP" directly below the touch keypad on the primary display. The message was designed be informative, but not intrusive to the novice user. As a result, the novice user maintained control of the dialogue with the online aid and could request the display of command-selection advice at later and possibly more appropriate times.

Subjective rating scales. In addition to the embedded performance measurement, subjective satisfaction with the online aids was assessed at the end of each information retrieval session. The instrument for user evaluation of the online aid consisted of a set of 12 bipolar rating scales and a final ranking of the three dialogue initiatives. The 12 bipolar scales consisted of an overall satisfaction scale and 11 individual adjective scales for determining specific subjective characteristics of the command-selection aids.

The 12 pairs of bipolar adjectives and the anchors for the accompanying seven-point scale are presented in Table 11. The first 8 individual bipolar adjectives (2 - 9) were selected from a study by Coleman (1985) that developed bipolar adjective scales for the evaluation of text editors

TABLE 11

Bipolar Adjective Scales for User Evaluation of the Online Aids

Overall Satisfaction

1.	UNSATISFACTORY	SATISFACTORY

Individual Bipolar Adjectives

2.	UNNATURAL	NATURAL
3.	UNDEPENDABLE	DEPENDABLE
4.	COMPLEX	SIMPLE
5.	SLOW	FAST
6.	INCOMPLETE	COMPLETE
7.	DISGUSTING	PLEASING
8.	UNCOOPERATIVE	COOPERATIVE
9.	USELESS	USEFUL
10.	UNADAPTIVE	ADAPTIVE
11.	STUPID	INTELLIGENT
12.	HINDERING	HELPFUL

Anchors for the Seven-Point Scale

extremely	quite	slightly	neutral	slightly	quite	extremely

by novice users. These 8 scales were found to be sensitive indicators of novice satisfaction with text editors. An additional 3 bipolar adjectives (10 - 12) were added to the evaluation instrument since the application task (information retrieval) and the evaluated software (an online advisory system) differed from the text-editing interfaces evaluated by Coleman (1985). In contrast to the 8 individual scales selected from empirical research, the 3 additional bipolar adjectives (UNADAPTIVE-ADAPTIVE, STUPID-INTELLIGENT, and HINDERING-HELPFUL) were chosen intuitively to assess the advice-giving characteristics of an online aid.

All 12 bipolar adjective scales were administered at the end of each aided session on a VT100 display with a Carroll Technology touch-entry device. An example of a displayed bipolar scale is shown in Figure 12. As illustrated, the adjective pairs were shown individually a display at a time. The left-right positioning of the adjective and its antonym was randomized with the restriction that an equal number of "positive" adjectives (e.g., FAST) occurred on both the left and right sides of the scale. Furthermore, the repeated administrations of the evaluation instrument for each dialogue initiative required randomizing the presentation order of the 11 individual bipolar scales.

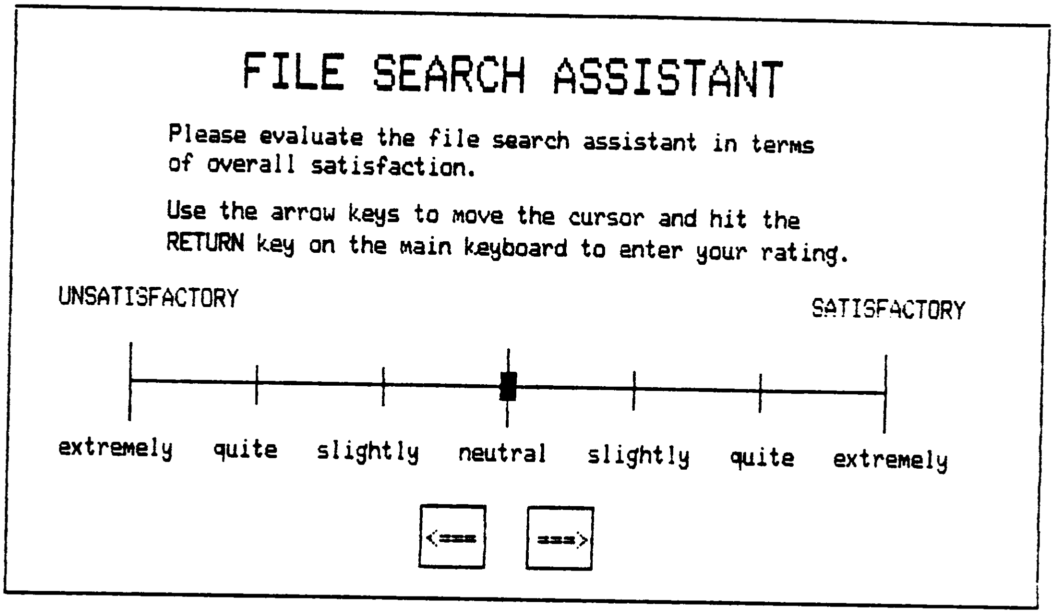


Figure 12. Display of the bipolar adjective rating scale.

Subjects were instructed to evaluate the file search assistance by moving a cursor with the displayed arrow keys to one of the seven positions corresponding to the seven verbal anchors. Cursor position was set initially at "neutral". All subjects were instructed and given practice on the software for evaluating the online aids. Both the instructions and examples for practice are given in Appendix P.

The final subjective evaluation technique asked subjects to rank order the dialogue initiatives in terms of preference from 1 to 3. A 1 indicated the most preferred dialogue and a 3 indicated the least preferred dialogue. This final evaluation occurred at the end of the final day of the experiment (Session 6). The form for collecting the ranked dialogue preferences is contained in Appendix Q.

Results and Discussion

Novice subject comparability. Comparisons between the control novices and the aided novices were necessary to evaluate online aiding. As a result, questions were raised regarding the similarity of novice subject groups. In particular, the heterogeneity of novice search performance in Experiment 1 may have resulted from a sampling problem whereby two distinct groups of novices were selected. The question posed in this analysis was whether the sample of 36 novices in Experiment 2 exhibited similar information retrieval behavior.

To test this sampling hypothesis, the last set of 12 training trials was analyzed for differences in average search performance and the variability in search performance of the 4 novice subject groups (control novices, frequency novices, sequence novices, and plan novices). The results of the one-way ANOVAs on total operations, number of different operations, total time, and total movement revealed no significant mean differences ($p > 0.05$) between novice subject groups. In addition, the results of the Moses rank-like test (Hollander and Wolfe, 1973) for detecting differences in search variability found no significant differences ($p > 0.05$) for the four dependent measures when comparing the control novice group to each of the aided groups. In total, there appeared to be no support for the idea that poor overall performance of the control novices was due to a sampling problem. Based on the training data, novices in the second experiment were comparable to control novices in terms of speed and variability in information retrieval.

<u>Aided search performance</u>: <u>Session and model effects</u>. Aided search performance was analyzed first to determine

whether there were any significant reductions in total operations, different operations, total time, or total movement over Sessions 3 through 5 as a result of the command-selection aids. In this analysis, novices receiving the three command-selection models (frequency, sequence, and plan-based) were compared against the control novices and experts of Experiment 1. Sessions were analyzed to determine whether there were any differential learning effects with the online command-selection aids.

The search performance measures which exhibited a significant difference between the five subject groups (frequency novices, sequence novices, plan-based novices, control novices, and experts) were total operations ($\underline{F}[4,55] = 2.76$, $\underline{p} = 0.0367$) and total time ($\underline{F}[4,55] = 4.50$, $\underline{p} = 0.0032$). The subject groups means and the results of the Newman-Keuls analyses ($\alpha = 0.05$) for total operations and total time are presented in Table 12. The means indicated no overall differences between the novices for both total operations and time, and a significant difference between novices and experts for total time. The lack of any mean differences between subject groups for total operations was probably a result of the conservative control of alpha error by the Newman-Keuls procedure and the large variability of novice search performance.

TABLE 12

Subject Group Means for Overall Aided Search Performance

	Subject Group				
Dependent Measure	Sequence Novices	Control Novices	Frequency Novices	Plan Novices	Experts
Total Time	103.07	95.95	94.32	93.21	67.67
Total Operations	10.9	11.0	9.9	9.1	7.7

Means with a common horizontal are not significantly different, Newman-Keuls ($\alpha = 0.05$).

The large session effects for total operations ($F[2,110] = 35.38$, $p = 0.0001$), different operations ($F[2,110] = 23.12$, $p = 0.0001$), total time ($F[2,110] = 72.79$, $p = 0.0001$), and total movement ($F[2,110] = 23.96$, $p = 0.0001$) paired with the lack of any session by subject group interactions ($p > 0.05$) indicates that a large amount of learning occurs irrespective of the type of aiding received. Thus, the session effects shown in Experiment 1 would be representative of the learning effects in this experiment with the subject group means adjusted accordingly.

The overall analyses of aided search performance indicated that aided novices performed no differently from control novices. From this perspective, the command-selection aids failed to assist novice users. However, the heterogeneity of novice search performance must be considered. Fast and slow novices should be compared against aided novices. Conducting these unbalanced ANOVAs would indicate whether the command-selection aids were capable of assisting slower novices without interfering with the fast novices. In performing these analyses, the assumption was made that both fast and slow novices were included in the aided groups.

Consistent with the previous balanced ANOVAs on sessions and subject groups, the results of these unbalanced ANOVAs revealed large session effects ($p = 0.0001$) for all search measures. The effect of subject group was more pronounced as well, with total operations ($F[5,54] = 5.93$, $p = 0.0002$), different operations ($F[5,54] = 3.29$, $p = 0.0116$), total time ($F[5,54] = 8.14$, $p = 0.0001$), and total movement ($F[5,54] = 3.62$, $p = 0.0069$) yielding significant differences between search means. Finally, the unbalanced ANOVAs revealed no significant ($p < 0.05$) interactions of subject groups and sessions.

Figure 13 shows the differences between subject groups and the results of the Newman-Keuls ($\alpha = 0.05$) analyses on the means for total operations and total time. The means and post hoc analyses for different operations and total movement were not displayed in Figure 13 since the pattern of results were similar to total operations. The means and Newman-Keuls tests shown in Figure 13 convey an interpretation of the aiding data that differs from the overall analysis reported in Table 13. In general, online aiding improved the performance of slower novices without interfering with the faster novices. These results were clear for total operations, different operations, and total movement, but were only partially true for total time.

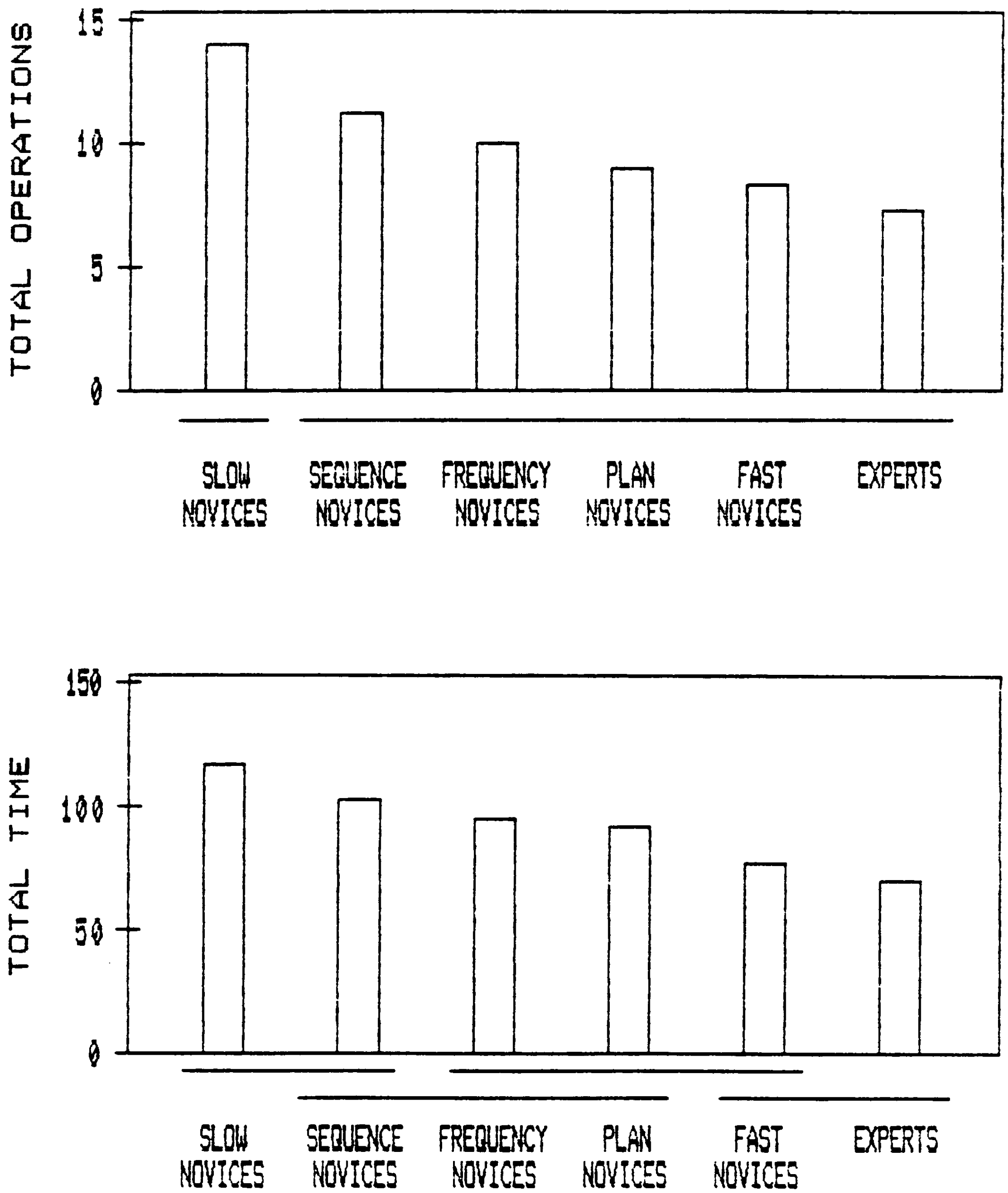


Figure 13. Comparison of fast novices, slow novices, aided novices and experts for total operations and time. Groups with a common horizontal line are not significantly different, Newman-Keuls (α = 0.05).

As shown in Figure 13, novices receiving the frequency and plan-based advice were performing at the level of fast novices in terms of total time. Sequence novices, although finding information as fast as other aided novices, appeared to be having difficulty and were retrieving information only slightly faster than slow novices. These results imply that frequency and plan-based models could be useful for aiding the slower novices without interfering significantly with the faster novices. Sequence models, however, were not as helpful in assisting the novice user with information retrieval and may even be intrusive for faster novices.

The slight superiority of the frequency and plan-based models probably rests on simplicity. Frequency profiles and plans, as implemented in this experiment, were presented only once a trial and remained on the display until completion of the trial. The permanence of the advice allowed subjects time to use and integrate the command-selection information with their own search strategies. The sequence-based advice, in contrast, was more dynamic and may not have allowed this integration. With sequence-based advice, novices were provided what search procedure to use next based on the previously selected search procedure. Thus, a large amount of constantly changing information was presented to the novice, making it extremely difficult to understand the underlying structure of the command-selection advice.

Aided search performance: Dialogue and order effects. Frequency and plan-based models seem to be capable of assisting some novice subjects. Therefore, the next step was to determine how the advice should be delivered to the novice users for effective assistance. The dialogue initiatives (user, computer, and mixed), the presentation order of the dialogues, and whether these two factors interacted with command-selection model were of interest. The initial three-way ANOVAs focused entirely upon aided novices.

The results of the 4 ANOVAs on search performance revealed significant effects ($p < 0.05$) for both dialogue initiative and the interaction of dialogue initiative by presentation order. Consistent with the previous analyses, type of command-selection model did not lead to any significant differences in search performance between the three aided groups. Moreover, interactions with the type of command-selection model were nonexistent with the two dialogue variables (initiative and presentation order).

Dialogue initiative was significant for total operations ($F[2,36] = 7.26$, $p = 0.0022$), different operations ($F[2,36] = 10.28$, $p = 0.0003$), total time ($F[2,36] = 5.03$,

$p = 0.0119$), and total movement ($F[2,36] = 4.48$, $p = 0.0183$). The means and the results of the Newman-Keuls procedure ($\alpha = 0.05$) for the total time and different operations are presented in Figure 14. The results for total operations and total movement were similar to total time and are not presented.

Figure 14 illustrates that mixed-initiative dialogues led to the worst performance with the command-selection aids. For every dependent measure, user- and computer-initiated dialogues were superior to the mixed-initiative dialogues. Furthermore, with the exception of the small significant differences displayed for different operations, user- and computer-initiated dialogues led to similar levels of search performance.

The poor search performance with the mixed-initiative dialogues was surprising since the dialogue theoretically possessed the ability to improve the command-selection strategies of the less efficient novices, while allowing the more proficient novices room to explore the advice at their own discretion. One hypothesis to explain the poor performance was that novice users may not be ready for the additional decision making introduced by a mixed-initiative dialogue. This additional level of decision making may result from the message: "If you want advice, press HELP."

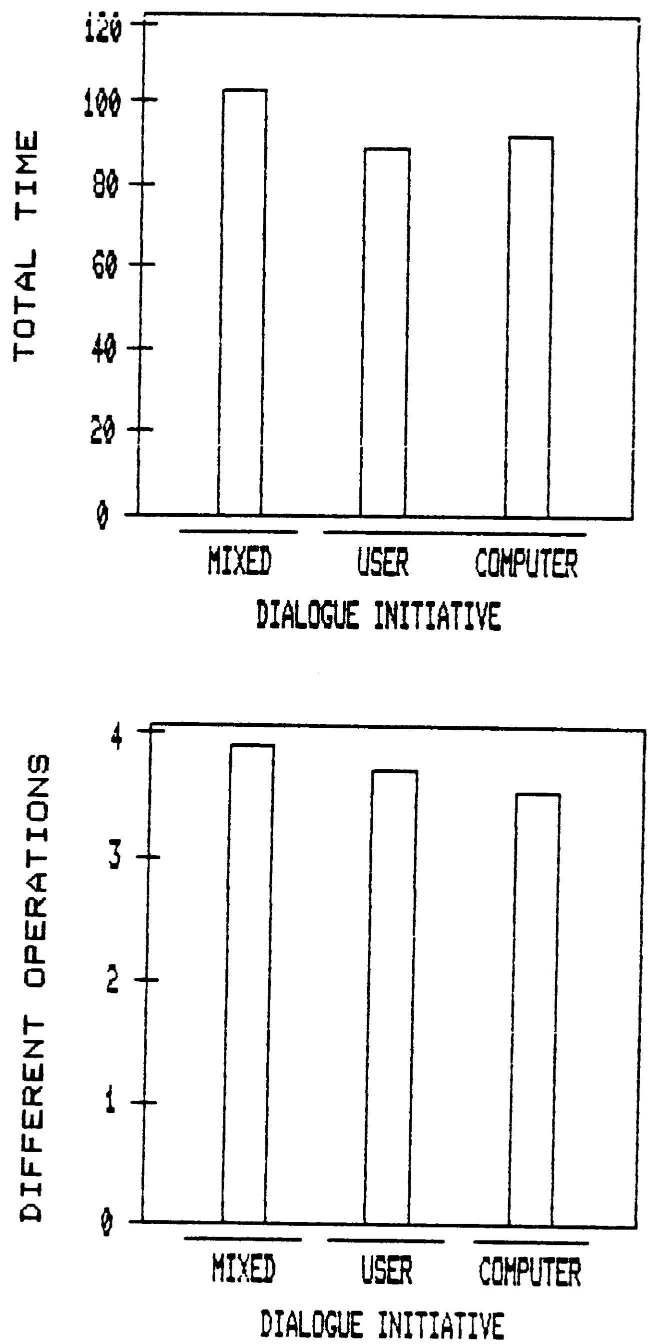


Figure 14. Effect of dialogue initiative on total time and different operations. Conditions with a common horizontal line are not significantly different, Newman-Keuls (α = 0.05).

In answering this question, novices would have to evaluate their current progress in search and would have to anticipate the value of the command-selection advice. As a result of these additional mental activities, novices would require more time.

Data were available to test the decision-making hypothesis due to the complete counterbalancing of the dialogues in the aiding phase of the experiment. The mixed-initiative dialogues were made available during each of the three aided sessions (3 - 5) to different novice subjects. As a result, mixed-initiative dialogues would be available to novice subjects at various stages of search skill and familiarity with the command-selection advice. For example, a novice receiving the mixed-initiative dialogue during the second or third session of aiding probably had used the command-selection advice and probably was more skilled in the search task than a novice in the first aiding session. With these knowledge and skills, a novice would be more capable of dealing with the mixed-initiative dialogues.

Fortunately, the dialogue initiative by presentation order interaction was significant for all dependent measures indicating that at least one of the dialogues was differentially effective with the six presentation orders.

This interaction was highly significant for total operations ($F[10,36] = 12.39$, $p = 0.0001$), different operations ($F[10,36] = 7.31$, $p = 0.0001$), total time ($F[10,36] = 15.09$, $p = 0.0001$), and total movement ($F[10,36] = 10.40$, $p = 0.0001$).

Figure 15 presents the results of the dialogue initiative by presentation order interaction in terms of total time. The three other search measures were not included in Figure 15 due to the similarity of results for all search measures and the large amount of data contained in this interaction. In this figure, the six possible presentation orders are represented by the sequence of three letters (i.e., MCU, MUC, UMC, UCM, CMU, or CUM), while the specific dialogue in a presentation order is denoted by a single letter (i.e., C, M, or U). For example, the symbol "CMU" with an "M" beneath it would represent the mixed-initiative dialogue administered in the second session of aiding for the subject group that was presented the dialogues in a computer-, mixed-, and user-initiated order. In the text, this condition will be denoted as CMU-M. Included in Figure 15 are the results of a Newman-Keuls analysis ($\alpha = 0.05$) for the means of the interaction.

Figure 15 clearly supports the decision-making hypothesis. Significant mean differences existed between

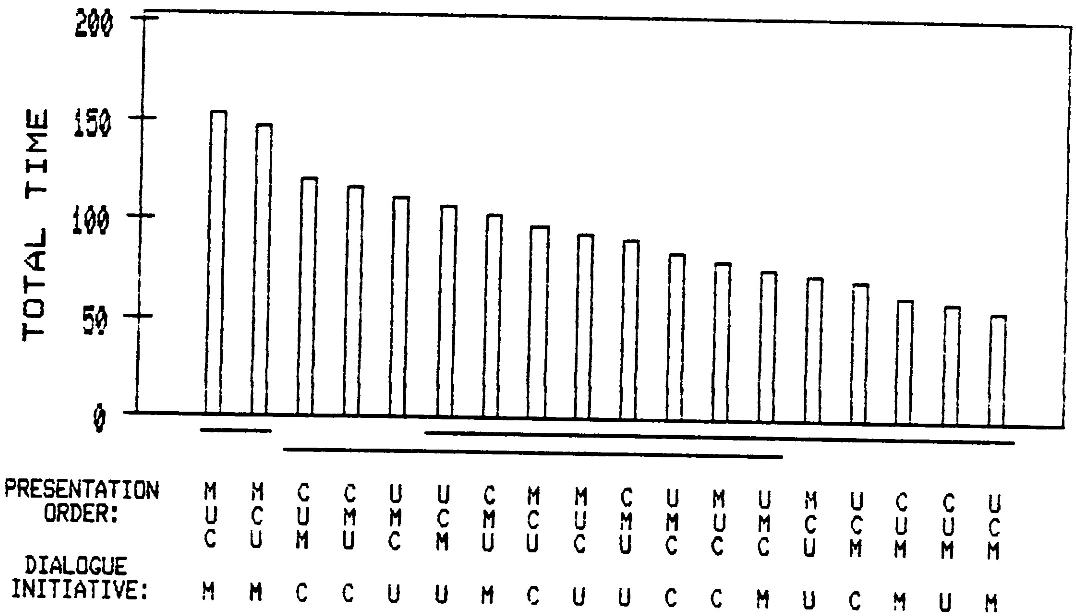


Figure 15. Dialogue initiative by presentation order interaction for total time. Conditions with a common horizontal line are not significantly different, Newman-Keuls (α = 0.05).

the presentation orders with mixed-initiative condition as the first dialogue (MCU-M, MUC-M) and all other combinations of presentation orders and dialogues. Dialogue presentation orders with mixed-initiative advice in the second (UMC-M, CMU-M) or third (CUM-M, UCM-M) aided sessions were far superior in terms of total time than the mixed-initiated sessions presented in the first aided session (MCU-M, MUC-M). In fact, the superiority of the mixed-initiated dialogues administered during the second and third sessions of aiding was demonstrated for every dependent measure (Newman-Keuls, $\alpha = 0.05$). Apparently, novice users were more capable of dealing with the mixed-initiative dialogues after receiving practice in the aided task.

The three-way ANOVAs proved to be useful for revealing a surprising sequence effect with the mixed-initiative dialogue. However, these ANOVAs did not provide comparisons with the control novices and experts. This comparison data would make it possible to recommend both effective and ineffective presentation orders for the three dialogue initiatives. Unbalanced ANOVAs were conducted for the four search measures to provide comparisons between the dialogue presentation orders and the control subjects in Experiment 1. The data were collapsed across command-selection models based on the lack of any significant differences ($p < 0.05$)

in previous analyses of search performance. Unbalanced analyses were performed with the entire control novice group and the novice group separated into slow and fast novices. Only the results of the more detailed analyses will be reported since the two analyses were in complete agreement.

The independent variables for these unbalanced ANOVAs consisted of the nine subject groups and the three sessions in which aiding could occur. The nine subject groups included fast and slow novices, experts, and the six dialogue presentation orders (MCU, MUC, UCM, UMC, CMU, and CUM). All novice groups had a sample size of 6, while the expert group had 12 subjects. The results of these unbalanced ANOVAs revealed significant main effects ($p < 0.05$) for subject groups and sessions, and a significant subject group by session interaction. Both the interaction of subject group and session and the main effect of subject group will be presented to illustrate the effectiveness of the six dialogue presentation orders. The effects of session will not be discussed since learning effects will be displayed in the presentation of the subject group by session interaction.

The subject group by session interaction was highly significant for total operations ($F[16,102] = 2.67$, $p = 0.0015$), different operations ($F[16,102] = 2.80$,

$p = 0.0009$), and total time ($F[16,102] = 2.91$, $p = 0.0006$). A plot of the means for this interaction in terms of total time is presented in Figure 16. Although the plot of the average times is very complicated, visual inspection of the results and Newman-Keuls procedures ($\alpha = 0.05$) revealed that the dialogue presentation orders of MCU and MUC were ineffective in the first aiding session. This conclusion was based on the comparisons of the MUC-M and MCU-M conditions with the slow novices for the dependent measures of total time, total operations, and different operations. From an aiding perspective, a dialogue initiative which leads to search performance no better than the performance of slow novices is not beneficial.

Beyond verifying the ineffectiveness of initial mixed-initiative dialogues, Figure 16 also suggests that the remaining dialogue presentation orders could lead to improved performance for the slower novices, while not interfering with the fast novices. Specifically, the dialogue presentation orders of UCM, UMC, CMU, and CUM never differed significantly from the fast novices in total time, total operations, or different operations (Newman-Keuls, $\alpha = 0.05$). Thus, there were methods of dialogue presentation that could facilitate novice performance.

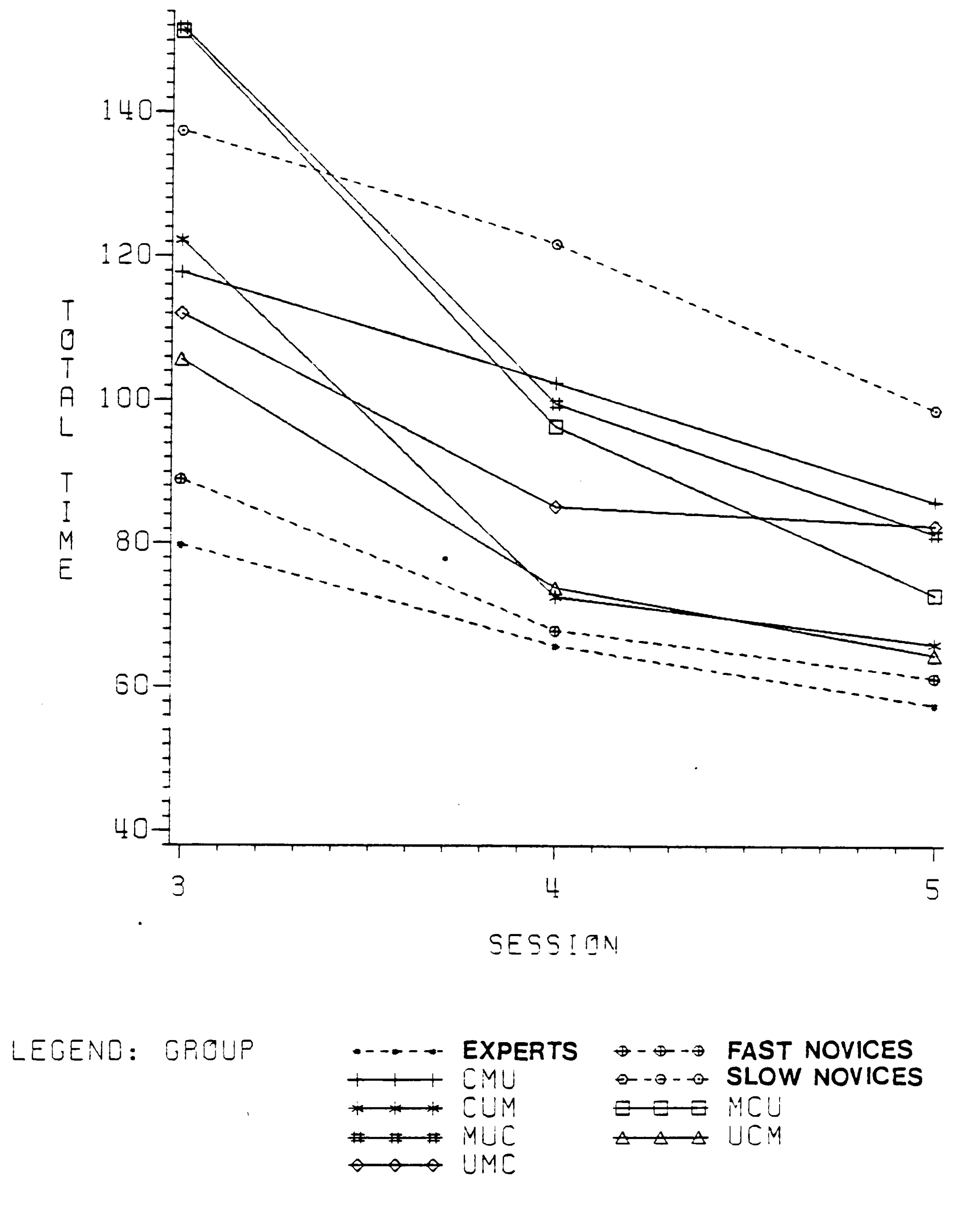


Figure 16. Dialogue presentation orders compared against slow novices, fast novices, and experts over sessions.

The dialogue initiative by presentation order interaction provided detailed information on the session to session effectiveness of different dialogues, but failed to give an overall indication of which dialogue order would be suitable for further study. The main effect of subject group supplies this information by comparing the dialogue presentation orders to the novice and expert groups. The search measures which yielded a significant subject group effect were total operations ($F[8,51] = 3.05$, $p = 0.0070$), different operations ($F[8,51] = 2.91$, $p = 0.0093$), and total time ($F[8,51] = 6.91$, $p = 0.0001$). The results of Newman-Keuls procedures ($\alpha = 0.05$) on the search means of these subject groups is presented in Table 13.

The dialogue presentation orders presented in Table 13 that consistently result in search performance comparable to fast novices and experts are UCM, CUM, and UMC. Not surprisingly, these dialogue orders have minimized the effects of mixed-initiative dialogues since these dialogues only occur in the last two aiding sessions. Therefore, the strongest recommendation that can be made in terms of dialogue sequence is that mixed-initiative dialogues should be presented only after users have had experience with the application task and the online advice.

TABLE 13

Dialogue Presentation Orders Compared Against Slow novices, Fast Novices, and Experts Overall

Total Operations		Different Operations		Total Time	
Mean	Subject Group	Mean	Subject Group	Mean	Subject Group
14.0	Slow Nov.	4.5	Slow Nov.	119.25	Slow Nov.
10.6	MUC	4.1	MUC	110.59	MUC
10.1	MCU	3.9	MCU	105.96	MCU
9.9	CMU	3.9	UMC	102.83	CMU
9.9	UMC	3.7	CUM	93.88	UMC
9.8	UCM	3.7	UCM	85.21	CUM
9.6	CUM	3.5	Experts	82.73	UCM
8.1	Fast Nov.	3.5	Fast Nov.	72.65	Fast Nov.
7.7	Experts	3.4	CMU	67.67	Experts

Means with a common vertical line are not significantly different, Newman-Keuls ($\alpha = 0.05$).

Interaction with the online aids. Aided search performance indicated that some novices can be assisted with information retrieval if complicated sequence models and highly interactive, mixed-initiative dialogues are avoided. However, to understand these results further requires investigation of user interaction with the online aid

Unfortunately, the issue of how frequently a user received command-selection advice was complicated by the implementation of sequence models. In contrast to the frequency and plan-based command-selection advice, sequence-based advice was allowed several times a trial. Thus, an increase in advice frequency was expected for the sequence models if advice per trial was used as the dependent measure. This measure accurately represents number of times advice was given on a trial. However, using only advice per trial may not be appropriate. For example, plan-based models offered a wealth of command-selection advice that was not reflected in the advice per trial measure since plan-based advice could only be given once a trial. To remedy this measurement problem, a second measure of advice frequency was developed. This dependent measure was the proportion of advised trials and was computed by counting the number of trials for which command-selection advice was given. The total number of advised trials was then converted into a proportion for the specific aiding condition.

The first set of analyses performed on the two measures of advice frequency (advice/trial and proportion of advised trials) paralleled the session and model analysis conducted for aided search performance. This analysis attempted to determine whether the different command-selection models influenced the presentation of advice over the three aided sessions. When considering advice per trial, the results of the two-way ANOVA found significant effects for type of command-selection model ($F[2,33] = 12.45$, $p = 0.0001$), session ($F[2,66] = 4.43$, $p = 0.0156$), and the interaction of models by sessions ($F[4,66] = 3.34$, $p = 0.0150$). A similar analysis on the proportion of advised trials failed to detect any statistical differences ($p > 0.05$) between models and sessions.

Advice per trial is illustrated in Figure 17 for novices receiving the three command-selection models across the 3 aided sessions. As illustrated, sequence novices received advice frequently during the first two aiding sessions. This high level of interaction for the sequence models supports an earlier hypothesis that frequent advice could have been responsible for the poor aided performance of sequence novices. However, both the plot of the model by

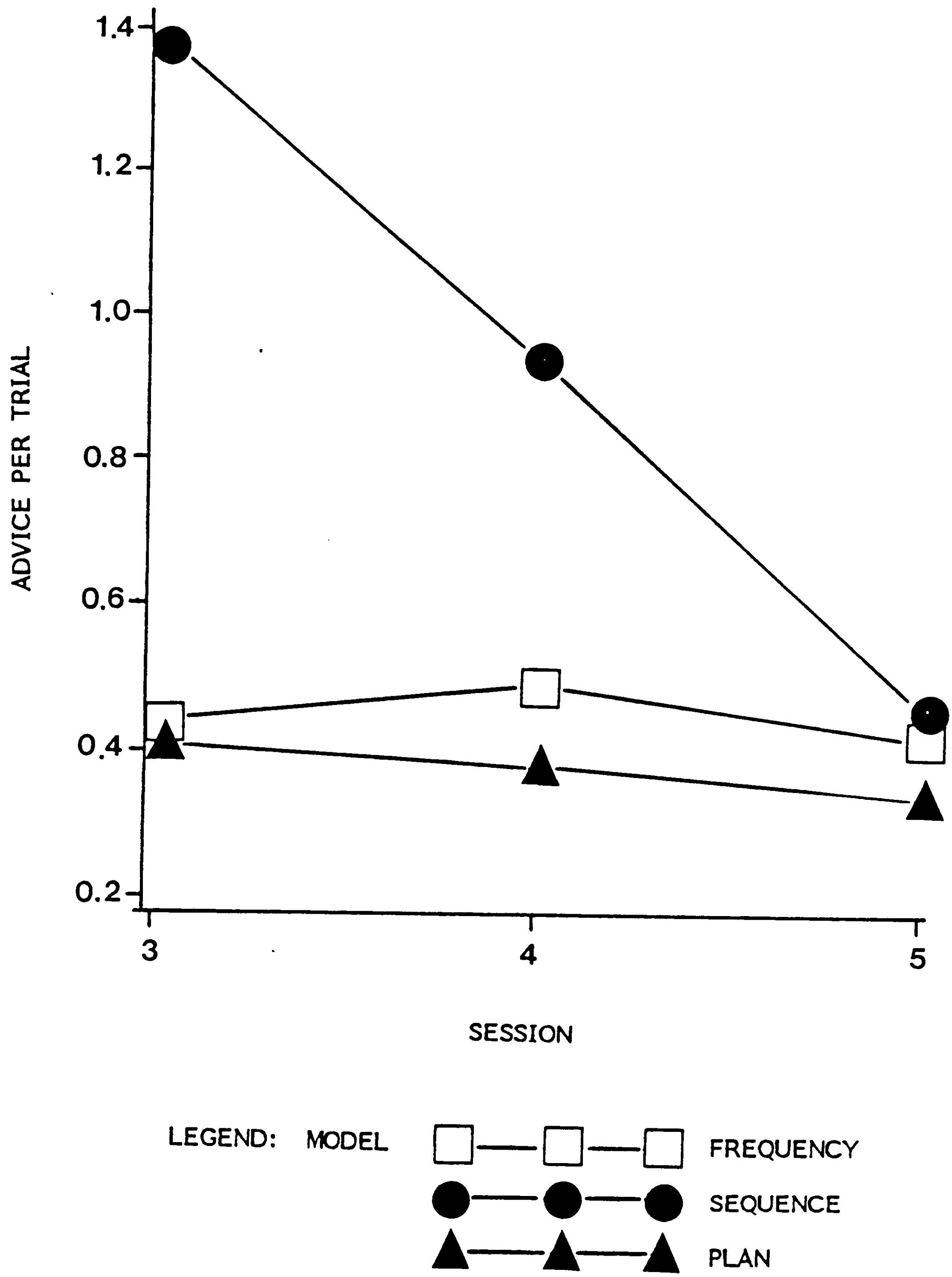


Figure 17. _Advice presentation frequency across sessions and command-selection models._

session interaction in Figure 17 and the results of the Newman-Keuls ($\alpha = 0.05$) procedures showed that advice frequency with the sequence aid decreased to the level of frequency and plan-based models over the course of aiding. The decrease in presentation frequency was probably the result of two factors. First, sequence novices were becoming skilled in command selection and may not have needed advice in the final aiding sessions. Second, in using the sequence model, novices may have realized the limitations of the command-sequence advice and reduced their requests for assistance.

The next set of analyses on advice presentation frequency (advice per trial and proportion of advised trials) paralleled the dialogue and order analyses conducted on aided search performance. Dialogue initiatives (user, computer, and mixed), dialogue presentation order, and the type of command-selection model were analyzed with a three-way ANOVA to determine whether advice presentation was influenced by the online dialogues implemented for the command-selection aids.

Not surprisingly, the results of these three-way ANOVAs for type of command selection model were in complete agreement with the previous model by session analyses on advice frequency. A significant main effect of command-selection model was found for advice per trial ($\underline{F}[2,18] = 10.48$, $\underline{p} = 0.0010$), with no corresponding significant difference ($\underline{p} < 0.05$) for the proportion of advised trials. As in the previous analyses on models and sessions, sequence models provided more advice (0.92 presentations/trial) than frequency models (0.44 presentations/trial) and plan-based models (0.38 presentations/trial). Newman-Keuls comparisons ($\alpha = 0.05$) verified these differences in advice presentation rates, showing that sequence models were significantly different from both frequency and plan-based models with no statistical difference between frequency and plan-based models.

Further outcomes of the dialogue and order analyses uncovered large main effects of dialogue initiative for both advice per trial ($\underline{F}[2,36] = 15.08$, $\underline{p} = 0.0001$) and proportion of advised trials ($\underline{F}[2,36] = 69.46$, $\underline{p} = 0.0001$). In addition, dialogue initiative was found to interact with type of command-selection model ($\underline{F}[4,36] = 2.81$, $\underline{p} = 0.0398$) and the dialogue presentation order ($\underline{F}[10,36] = 2.41$, $\underline{p} = 0.0262$) for the proportion of advised trials. Both of these interactions were influenced strongly by the dialogue initiative main effect, and as a result will not be presented.

The means and the results of Newman-Keuls procedures ($\alpha = 0.05$) for the three dialogue initiatives are presented in Figure 18. Both dependent measures revealed significant increases for advice presentation with the computer-initiated dialogues. Figure 18 also illustrates that requests for advice did not increase from the user-initiated to the mixed-initiated dialogues. In fact, if both search performance and advice frequency are considered, mixed-initiative dialogues appear to be relatively ineffective in changing novice search behavior.

Transfer search performance. The results described in this section focus on the performance of the aided subjects during the final session of the experiment. In this final session, aided novices retrieved information without the online aid. The purpose of this analysis was to determine if novices acquired any skills through the use of the online aids that facilitated search performance above and beyond mere practice. Several questions were asked in this transfer analysis. First, were aided novices finding information faster and more efficiently than the control novices in Experiment 1? Second, if aided novices were finding information faster, then were these aided novices performing at an expert's level of search proficiency? Finally, did the online aiding lead to any improvements in

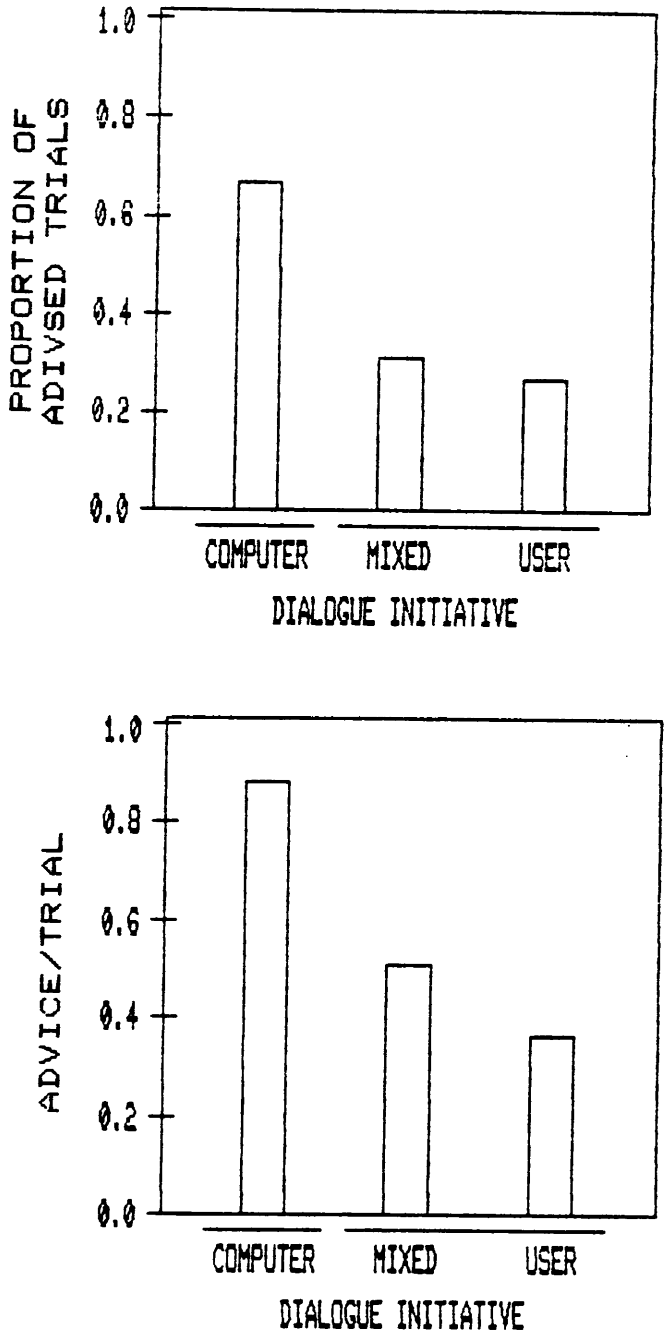


Figure 18. Advice presentation frequency for dialogue initiatives. Conditions with a common horizontal line are not significantly different, Newman-Keuls ($\alpha = 0.05$).

the variability of search performance for the novice subject groups?

The first analysis conducted was an overall transfer analysis on the aided novices, control novices, and experts for total operations, different operations, total time, and total movement in the last retrieval session. The results of the one-way MANOVA revealed no overall search performance differences between the aided novices, control novices, and experts, Wilks' $\Lambda(4,55) = 0.6544$, $p = 0.1114$. From this overall analysis it could be concluded that search performance was not changed as a result of the online aiding. However, the heterogeneity of novice search performance demonstrated in Experiment 1 may have clouded these results. To investigate this hypothesis, control novices were separated into groups previously described as slow and fast novices. Overall transfer performance was then reanalyzed for the six subject groups in a MANOVA model with unbalanced sample sizes. Once again, the assumption with the separated novice groups was that both fast and slow novices would be included in the groups of aided novices. The results of this MANOVA indicated that there were overall search performance differences between aided novices, fast and slow novices, and experts, Wilks' $\Lambda(5,54) = 0.4437$, $p = 0.0016$.

Due to the overall search differences between subject groups, detailed unbalanced ANOVAs on each dependent measure were conducted. Statistical differences between the six subject groups were found for total operations ($\underline{F}[5,54] = 4.84$, $\underline{p} = 0.0011$), different operations ($\underline{F}[5,54] = 3.05$, $\underline{p} = 0.0169$), total time ($\underline{F}[5,54] = 7.14$, $\underline{p} = 0.0001$), and total movement ($\underline{F}[5,54] = 4.11$, $\underline{p} = 0.0032$). The search means for the six subject groups are displayed in Figure 19. Included in Figure 19 are the results of the Newman-Keuls procedures ($\alpha = 0.05$).

The large and consistent differences shown in Figure 19 strongly indicated that aided novice subjects were retrieving information faster and more efficiently than the slower novices. Aided novices, when compared to slow novices, retrieved information approximately 60% faster, used 60% fewer total search operations, were 50% more accurate in terms of line movement, and constrained their use of search procedures by 75%. In fact, during transfer aided novices were retrieving information just as efficiently as the fast novices and experts irrespective of the type of command-selection advice administered in the three previous sessions. All three command-selection aids appear to have improved the search performance of the slower novices without impairing the faster novices.

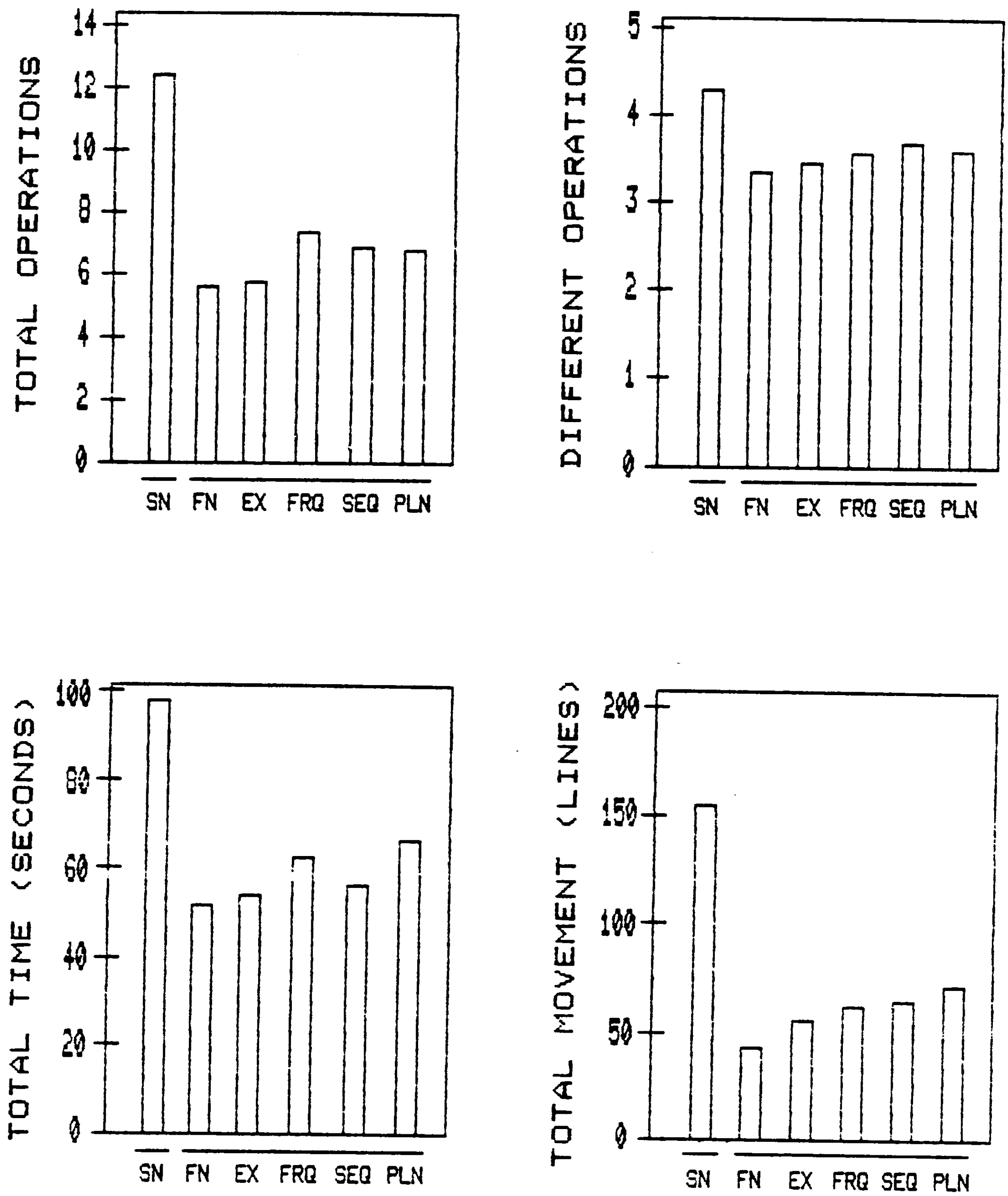


Figure 19. Transfer search performance for slow novices (SN), fast novices (FN), experts, (EX), frequency novices (FRQ), sequence novices (SEQ), and plan novices (PLN). Groups with a common horizontal line are not significantly different, Newman-Keuls (α = 0.05).

Closely associated with the issue of average search performance in transfer was the question of whether aided novices became more homogeneous in search performance. That is, did the command-selection aids reduce the large variability in novice search performance? To answer this question, a Moses rank-like test (Hollander and Wolfe, 1973) was conducted for total operations and total time. Only total operations and total time were focused on in transfer since these were the search measures which demonstrated significant differences ($p < 0.05$) in variability of control novices and experts in Experiment 1.

The first two Moses rank-like tests were performed on the dispersion differences between control novices and experts in the transfer session. The results of these tests confirmed the dispersion differences between control novices and experts in the transfer session for total time ($W[4,4] = 26.0$, $p = 0.014$), but failed to detect dispersion differences for total operations ($W[4,4] = 23.0$, $p = 0.1$). Therefore, comparisons of the variability in transfer performance between the three aided groups, and the novices and experts in Experiment 1 only focused on total time. Box plots of this transfer data for all five subject groups are shown in Figure 20.

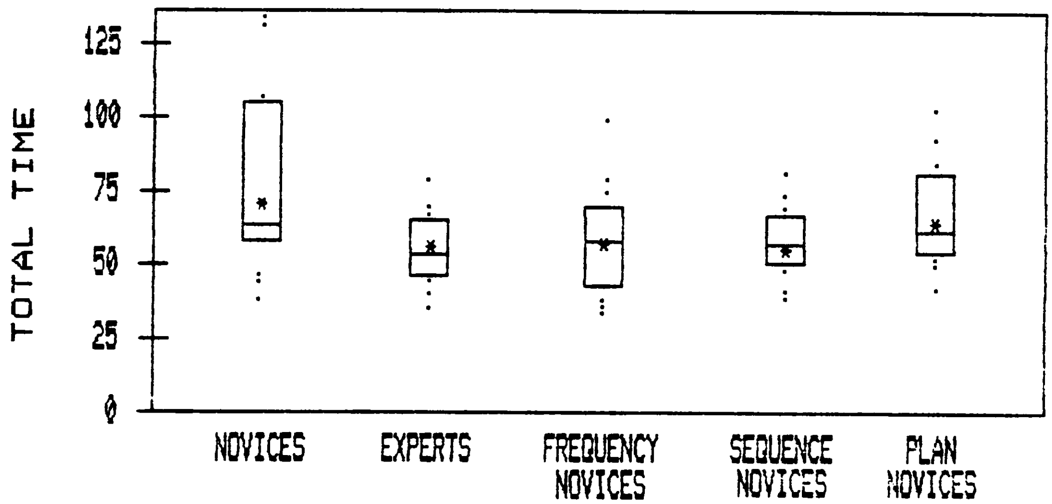


Figure 20. Total times for aided novices, control novices, and experts in the transfer session.

Figure 20 shows the differences in search time dispersion for the five subject groups. The online aiding appeared to decrease the variability within the novice groups. Estimates of group variances and detailed comparisons of the aided novice groups with the novices and experts in Experiment 1 are provided in Table 14. As shown in Table 14, the variability of each aided group was compared individually with the control novices and experts using the Moses rank-like test. With the exception of the frequency novices, online aiding decreased variability in transfer times so that aided novices groups were beginning to resemble experts in terms of group variation. Together with the demonstrated differences between slow novices and aided novices, these results suggest that command-selection aids improved the performance of slower novices thereby making group performance more consistent.

Search strategy. The improvements in performance and transfer lead to the question of whether aided novices had changed their search strategies during the course of the experiment. The results of Experiment 1 found that the slower novices tended to use the SCROLL UP, SCROLL DOWN, and ZOOM OUT more frequently than the faster novices and experts. Therefore, the goal of the search strategy analysis was to determine whether novices decreased the use

TABLE 14

Comparisons of the Variability of Total Time in Transfer for Aided Novices, Control Novices, and Experts.

	Experiment 1 Subject Groups	
Experiment 2 Subject Groups	Novices σ^2 = 1046.60	Experts σ^2 = 110.35
Frequency Novices σ^2 = 338.74	20.0 (0.343)	25.0 (0.029)
Sequence Novices σ^2 = 108.74	24.0 (0.057)	20.0 (0.343)
Plan Novices σ^2 = 235.49	22.0 (0.171)	24.0 (0.057)

Main entries are rank sum statistics *W*(4,4).
Values in parentheses represent *p*-values.

of these search procedures as a result of having online command-selection assistance.

The analysis of the search strategy paralleled the analysis conducted in Experiment 1. In this experiment, however, strategy analysis was conducted immediately at a detailed level comparing frequency novices (12 subjects), sequence novices (12 subjects), plan novices (12 subjects), slow novices (6 subjects), fast novices (6 subjects), and experts (12 subjects). The proportions of search procedure selection for each subject group were analyzed with a MANOVA to check for overall differences in search strategies. The results of this one-way MANOVA revealed a significant Wilks' criterion, $\Lambda[5,54] = 0.1607$, $p = 0.0063$, indicating that some combination of these search procedures were selected differently between subject groups. Individual unbalanced ANOVAs were conducted subsequently to investigate these differences in search procedure selection. The results of these ANOVAs showed significant differences in the selection of SCROLL UP ($F[5,54] = 2.41$, $p = 0.0480$), SCROLL DOWN ($F[5,54] = 2.44$, $p = 0.0455$), and ZOOM OUT ($F[5,54] = 5.10$, $p = 0.0007$) for the six subject groups. Figure 21 displays the selection proportions of these three search procedures for each of the six subject groups. Included in Figure 21 are the results of Newman-Keuls procedures ($\alpha = 0.05$) on these average proportions.

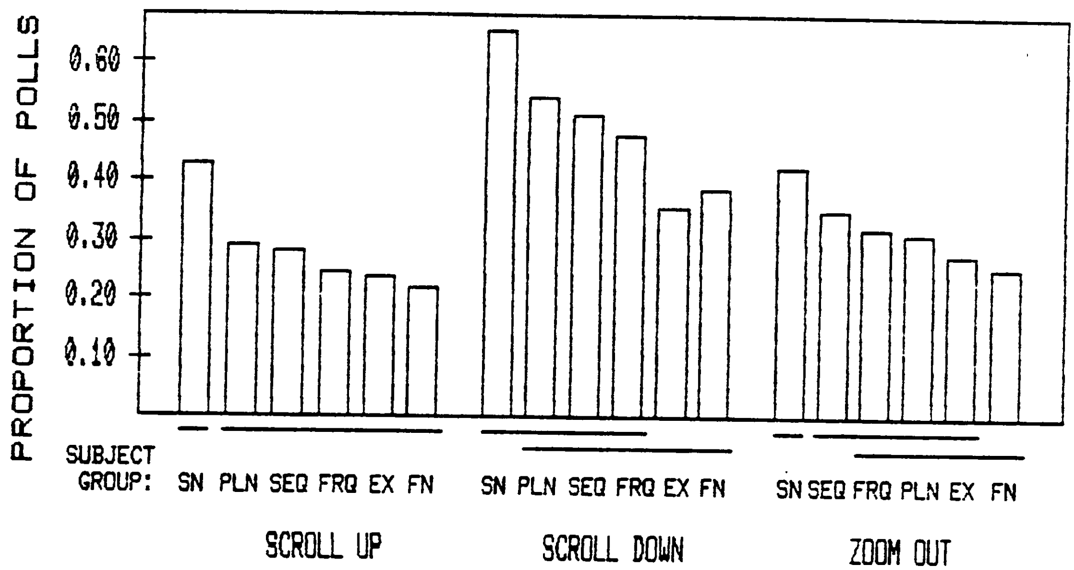


Figure 21. Significant differences in search procedure selection for aided novices (frequency - FRQ, sequence - SEQ, plan - PLN), slow novices (SN), fast novices (FN), and experts (EX). Groups with a common horizontal line are not significantly different, Newman-Keuls ($\alpha = 0.05$).

Figure 21 demonstrates the decrease in the selection of the SCROLL UP and ZOOM OUT by novices receiving command-selection advice. Aided novices were selecting these search procedures less often than the slow novices and were approaching the selection rates of expert subjects. The reduction in the selection of SCROLL DOWN was not as large. Aided novices decreased the use of the SCROLL DOWN to a level comparable to experts and fast novices, but this reduction was not large enough to lead to significant differences between aided and slow novices.

As a result of receiving command-selection advice during the experiment, aided novices were gaining command-selection skills in the experiment and some knowledge of the file hierarchy. Diminished use of the scrolling procedures was indicative of the acquisition of command-selection skill by aided novices since other procedures like SEARCH or INDEX can typically position a file quickly to a desired position. Likewise, the decreased use of ZOOM OUT was an indication of aided subjects learning the structure of the file hierarchy. The ZOOM OUT procedure is only used when subjects are in the wrong file. The different command-selection models did not lead to any significantly different search strategies. Detailed statistical procedures may detect these differences during aiding or transfer, however, these analyses were not conducted due to small sample sizes associated with search problems and subjects.

Satisfaction with the online aids. Subjective responses to the command-selection aids and dialogue initiatives were measured through a set of bipolar adjective scales administered at the end of each aiding session and a preference ranking of the dialogue initiatives at the end of the experiment. These two dependent measures were analyzed separately. The purpose of these analyses was to determine which type of online command-selection aid and dialogue initiative was most desirable from the user's perspective.

The bipolar adjective scales were analyzed within an ANOVA model. Parametric procedures were selected over nonparametric since the 12 bipolar scales provided for a multi-variable analysis. In this situation, parametric tests are well suited for protecting against the inflation of alpha error. In addition, the analysis of bipolar scales was complicated due to missing data points. Three novices with user-initiated dialogues (two frequency novices and one sequence novice) did not request advice from the online aid. These subjects could not be expected and were not asked to evaluate the online aid for those specific conditions. Therefore, unbalanced ANOVAs were employed using the method of weighted means to estimate the missing values (Winer, 1971).

The analysis of the bipolar scales was separated into three parts. The first analysis was a two-way ANOVA on the overall satisfaction scale. The two factors included in this unbalanced ANOVA were type of command-selection model and dialogue initiative. The results of this ANOVA did not find any statistically reliable ($p < 0.05$) differences in user satisfaction that could be attributed to the command-selection model or the dialogue initiative.

The analysis then proceeded to the individual bipolar adjective scales. These scales were analyzed in two groups. The first set of bipolar scales analyzed were part of the evaluation instrument developed and validated by Coleman (1985). These scales were the first 8 individual bipolar adjectives displayed in Table 11. These 8 bipolar scales were separated from the other 3 individual scales to avoid confounding the results of a previously developed and tested evaluation tool with other less well selected and validated scales (bipolar adjective scales 10 - 12).

To safeguard the alpha error, a single ANOVA was conducted on the 8 individual scales from Coleman's (1985) user evaluation instrument. Rating scale in this ANOVA was treated as a within-subjects, classification variable and was used to determine if the scale ratings were influenced by either the command-selection model or the dialogue initiative. However, due to computational limitations, missing values in this ANOVA had to be eliminated. For this purpose, means were computed across the replicated and counterbalanced dialogue orders reducing the cell size by 1/2 and effectively eliminating any missing values. The results of this reduced ANOVA revealed a significant scale by model interaction ($\underline{F}[14,105] = 1.87$, $\underline{p} = 0.0380$) for the 8 individual bipolar scales.

To further investigate the scale by model interaction for these 8 bipolar scales, 8 individual unbalanced ANOVAs were conducted. The results of these ANOVAs yielded statistically different ratings of the command-selection models for the DISGUSTING-PLEASING bipolar adjectives ($\underline{F}[2,33] = 3.37$, $\underline{p} = 0.0465$) and the UNDEPENDABLE-DEPENDABLE bipolar adjectives ($\underline{F}[2,33] = 4.79$, $\underline{p} = 0.0149$) The mean ratings for these two bipolar scales are presented in Figure 22 along with the results of the Newman-Keuls comparisons ($\alpha = 0.05$) on these means.

The bar charts in Figure 22 illustrate the more favorable response given to the plan-based models. The novices in the plan-based group rated the assistance as slightly pleasing and slightly dependable. These positive ratings of the plan-based advice are to be contrasted with the sequence advice which was rated halfway between neutral and slightly

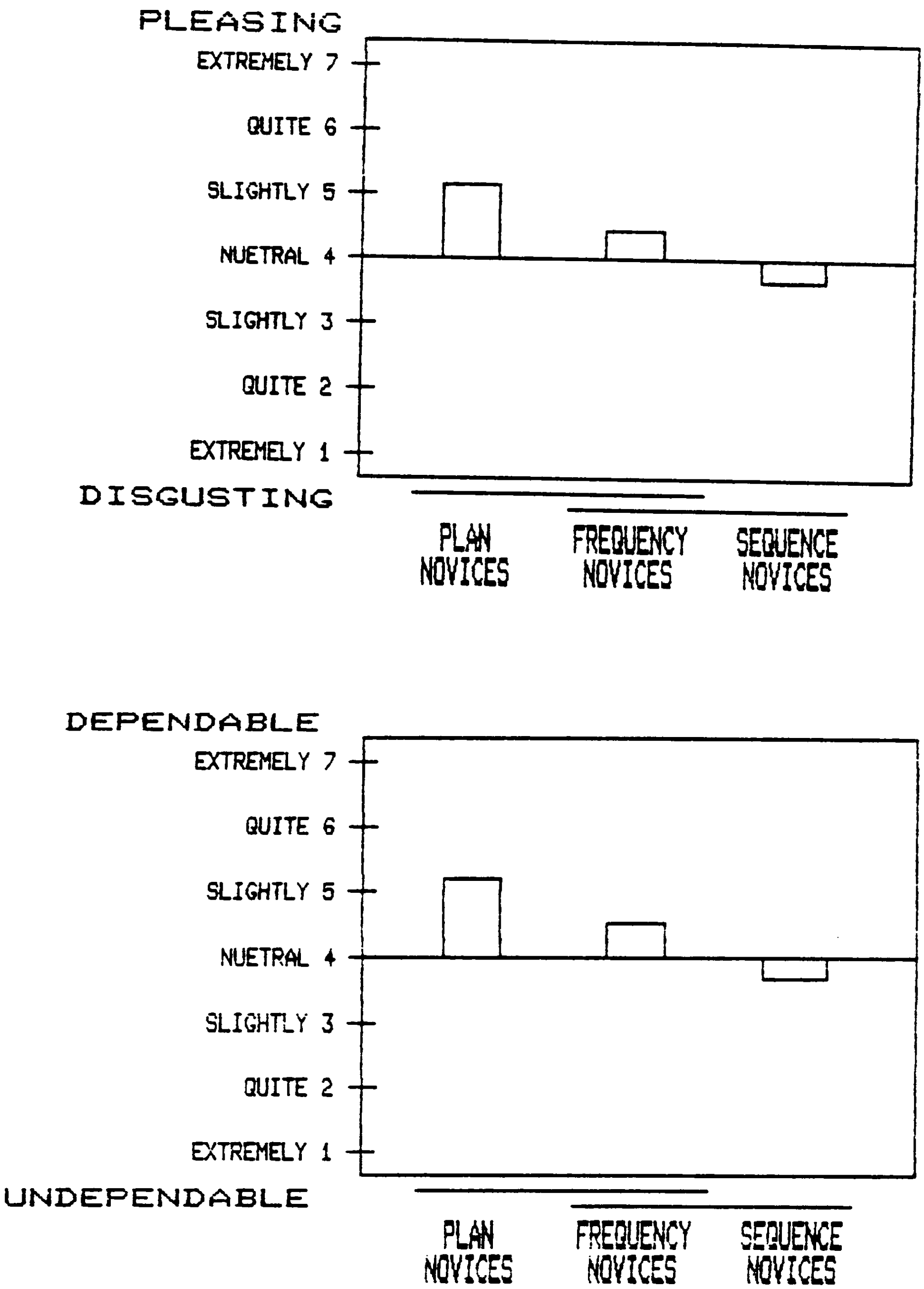


Figure 22. Significant differences in the subjective ratings of the command-selection aids. Groups with a common horizontal line are not significantly different, Newman-Keuls ($\alpha = 0.05$).

disgusting or slightly undependable. Thus, the simple and unchanging sequence of search procedures supplemented with verbal explanations may be necessary ingredients for improving the subjective quality of command-selection advice.

The second set of bipolar adjectives (UNADAPTIVE-ADAPTIVE, STUPID-INTELLIGENT, and HINDERING-HELPFUL) were analyzed similarly. An initial balanced ANOVA based on the mean ratings of subjects from replicated dialogue orders was conducted to safeguard alpha error. The three-way ANOVA included scale as a factor to determine if ratings on individual bipolar adjectives were influenced by the command-selection model or the dialogue initiative. The results of the ANOVA revealed no significant interactions with scale ($p < 0.05$). Further analyses were abandoned and the results accepted as indicating the insensitivity of these intuitively selected scales.

The final subjective analysis was a nonparametric test of the preference rankings for the three dialogue initiatives. A one-way, blocked Friedman rank sum test was used for each aided group (frequency, sequence, and plans) to determine which dialogue initiative was preferred. Significant differences in preference for the three dialogues were found with the frequency model ($\underline{S}' = 12.5$, $\underline{p} < 0.005$), and with the sequence model ($\underline{S}' = 8.17$, $\underline{p} < 0.025$). No significant differences in preference were found for dialogue initiatives with the plan-based model ($\underline{S}' = 2.0$, $\underline{p} > 0.10$). Individual rank sums of the three dialogue initiative for each command-selection model are provided in Figure 23. Included in Figure 23 are the results of the multiple comparisons on the individual rank sums ($\alpha = 0.05$) for the frequency and sequence groups (Hollander and Wolfe, 1973). Care should be taken when interpreting Figure 23 since a large rank sum preference indicates a lesser preferred dialogue.

Figure 23 displays the lack of preference for the computer-initiated advice in the frequency and sequence models. Computer-initiated dialogues with these command-selection models could be extremely intrusive to a user's search strategy. Subjects could be interrupted and provided command-selection advice without any supporting explanations for the search procedures suggested. This intrusion hypothesis also was supported by the lack of significant preference differences for the plan-based aid. Computer-initiated dialogues with the plan-based model provides information on how to use the command-selection advice. Therefore, the lack of a preference difference

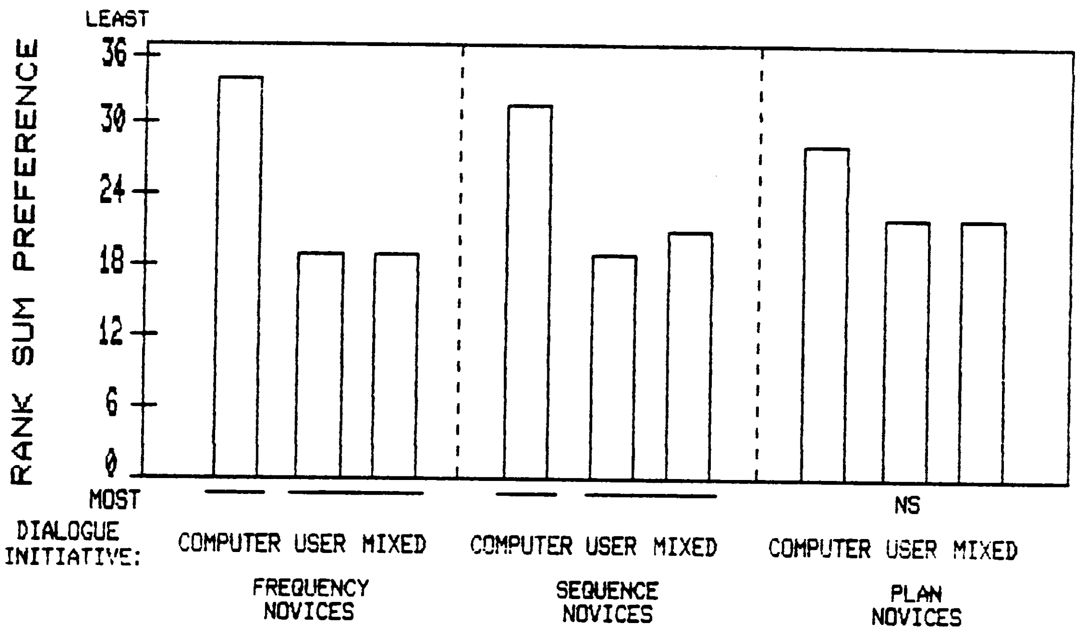


Figure 23. Preference rank sums of the dialogue initiatives for each aided group of novices. Conditions with a common horizontal line are not significantly different, Newman-Keuls (α = 0.05).

between dialogues may indicate a willingness on the part of some novice subjects to use the computer-initiated, plan-based advice.

<u>Summary</u>

The command-selection aids were capable of assisting slower novices with information retrieval and were suitable for training these novices on efficient search strategies resulting in a significant improvement in transfer search performance. In terms of group performance, these changes led to a decrease in the heterogeneity of novice search performance. However, the experiment also revealed that the command-selection models and the dialogue-initiatives must be designed carefully to avoid providing complicated advice and to avoid an initial highly interactive dialogue.

GENERAL DISCUSSION

Command-Selection Models

Why were the online aids successful in providing advice to the slower novices? The answer may reside in the construction of command-selection models based on the search clusters. Development of the search clusters defined a set of component search tasks for which consistent command-selection advice could be given to the novice user. That is, novice users would be presented, at the very least, the same set of search procedures for similar types of search problems. This provides the novice a chance to practice and to process the command-selection information consistently over several trials. With consistent practice, the training principles of Schneider (1985) suggest that users will be more likely to learn and possibly automate the necessary search skills.

Improvements as a result of consistent practice are best supported by the performance of the novices receiving the plan-based models. With the plan-based models novice users would be provided the same set of search procedures as advice for similar types of search problems. Moreover, in the search plan explanations subjects would be told explicitly what aspects of the search problem to look for and how the search procedures should be used. The novice user was provided very consistent advice related to the search problem and should be expected to learn the search task. In fact, subjective evaluations of the plan-based model were indicative of the pleasing and dependable advice administered when compared to the sequence model.

Unfortunately, consistent practice can only play a small role with frequency and sequence models since the component search tasks were not explicitly presented. However, another related theory, that of learning by active learning (Carroll and Mack, 1984; 1985), may be useful in understanding the improved transfer performance of novices receiving frequency and sequence advice.

With frequency and sequence advice, novices were provided, by definition, an incomplete model (Carroll and Mack, 1985) of command selection. Verbal explanations for using the suggested search procedures were not provided with the frequency and sequence advice. In order to use the frequency and sequence advice novices would have to explore actively the search procedures. Therefore, as a result of learning by doing (Carroll and Mack, 1984), and possible self-elaborations (Mayer, 1981), novice subjects would acquire search strategies that would facilitate improved transfer performance. The improved transfer search performance of frequency and sequence novices over the slow novices suggests that a more active learning environment existed with these command-selection aids.

There may be many other reasons why the command-selection models were successful. However, one of the most important reasons that should not be overlooked is feedback. Eberts and Brock (1984) in reviewing computer-based instruction and Williges, Williges, and Elkerton (in press) in reviewing software interface design have both noted the importance of feedback as a design principle. A human-computer interface should be closed-loop with feedback to the user about quality of their performance and the steps necessary to cause some desired action.

Clearly, novices were provided additional feedback with these command-selection models that the slower novices did not have. Similar to the interpretation given by Carroll and Carrithers (1984), the feedback given with the command-selection advice limited the number of search commands allowing novices to identify and correct inefficient search strategies and improve transfer performance. Still, feedback must be applied appropriately. Too much, or inappropriate feedback, as was given with the sequence models, may degrade aided performance and should be avoided in computer-based learning environments (Robinson and Knirk, 1984).

As a final word on command-selection models, the interpretation of success must be considered. Success in this experiment meant that extremely slow and inefficient novice search performance was not observed with the command-selection aids. If success is measured by overall mean differences of groups, then the merits of these command-selection aids are questionable. How might the lack of overall differences be explained?

First, the question of model optimization must be asked. That is, was each of the command-selection models the best possible behavioral implementation? Despite the time, effort, and thought put into designing the command-selection models, there were indications that improvements could be made. For example, the problem of complicated and frequent advice was demonstrated for the sequence model. Methods and procedures for limiting the advice might result in making the sequence model viable. Similarly, due to the cognitive nature of the search plans there was probably room for improvement either through iterative design procedures (Sullivan and Chapanis, 1983) or graphic presentations (Sebrechts, Deck, and Black, 1983). Thus, conclusions on the relative effectiveness of the command-selection models must be interpreted carefully since a slightly different implementation could change the results and possibly lead to the superiority of a specific model for aiding novice users.

Related to the issue of optimization was the experimental design used in this study. In order to investigate dialogue initiatives, aided novices were given several dialogues to interact with the online aid. The lack of a consistent dialogue could have dramatically affected search performance and eliminated any differences between models. A between-subjects design with dialogues is recommended in future research. Therefore, more research is necessary to further understand many of these modeling issues.

Dialogue Initiatives

As shown in this experiment, the relative success of the online command-selection aids was also influenced by the dialogue initiative. In fact, the most surprising result was the poor performance of aided subjects receiving mixed-initiative advice early in the experiment. Aided subjects did not seem to be ready for the additional decision making required to determine whether advice should be presented or not. The conclusion reached in this experiment was that the highly interactive mixed-initiative dialogue should be presented only when the novice becomes familiar both with the task and the command-selection advice to avoid any performance decrements. In online training, even temporary performance decrements may rob the learner of additional trials and cancel any time compression benefits thought to be crucial to the development of cognitive and high-performance skills (Eberts and Brock, 1984; Schneider, 1985).

This conclusion coincides with principles advanced by Robinson and Knirk (1984) for presenting instructional assistance in training interfaces. Robinson and Knirk (1984) state that instructional aids should not add unnecessary dialogue to training. Unfortunately, the mixed-initiative dialogues introduced an implied dialogue when suggesting that command-selection advice was available. Novices were having to make additional decisions about receiving command-selection advice. Similar to the results found by Carroll and Kay (1985) with scenario machines, the coherence of the task may have been destroyed by the additional prompts and feedback in the training dialogue.

Finally, when implementing dialogues, the preferences of users should be considered. From this investigation, it is clear that unless the command-selection aid provides verbal explanations for using the advice (i.e., plan-based advice), users will not like to have the computer determine when advice should be given. Therefore, user-initiated dialogues are recommended for the command-selection assistance presented in this experiment due to the performance limitations of the mixed-initiative dialogues and the preference limitations of the computer-initiated dialogues. This recommendation is consistent with the guidelines for human-computer interfaces (Williges and Williges, 1984) and the online help research of Cohill and Williges (1985). However, further research should be conducted to determine if computer- and mixed-initiative dialogues can be improved to encourage more active exploration and browsing (Carroll and Mack, 1984; Cohill and Williges, 1985) of the software interface by inexperienced users.

Information Retrieval Skills

A final noteworthy result of these experiments was the wide ranging skills of novice subjects learning to use the information retrieval interface. Some novices, after initial training, were just as skilled as more experienced subjects. Other novices were dreadfully slow in learning how to use the information retrieval system. The large differences in search performance existed even though all subjects had received one tutorial session on the database and search procedures, and one session of practice on the actual task. From these results, the conclusion was drawn that novice performance resembled the acquisition of high-performance skills. However, the match between information retrieval skills in the experiment and the high-performance skills described by Schneider (1985) was not perfect. Schneider (1985) stated that high-performance skills may take 100 hours or more to learn and may lead to substantial failure rates in learners. Clearly, information retrieval in this experiment did not approach this level of difficulty.

Therefore, additional questions must be asked surrounding the heterogeneity of novice search performance to gain a fuller understanding of the diverse skills of novices in the information retrieval task. Some of these questions might be: How robust is this phenomenon? Was the effect introduced by the training procedures? Does the effect magnify without training? Can novice skills be predicted? Until further research answers some of these questions, attempts at aiding novices will be limited.

Nevertheless, these large individual differences, or what has been referred to as heterogeneity of search performance, provided a unique opportunity to investigate skill differences in the laboratory. In fact, from this investigation, and other previous investigations (Elkerton and Williges, 1984; 1985), a few reasonable hypotheses can be formulated as to why heterogeneity of novice search performance was observed. In previous investigations (Elkerton and Williges, 1984: 1985) novices were only required to search one file at a time. In the present investigation subjects were asked to search through several files in a hierarchy. As a result, data organization was much more complicated. In addition to having to know where the information was in a file, novices had to know where this file was in the hierarchy.

Why might the complicated organization lead to widely varying search performance? The answer may be in the conceptual structure that novices ascribe to the database. The database in the first two studies could be conceived of as a linear list. Both investigations (Elkerton and Williges, 1984; 1985) have demonstrated that novices treat the database as a list due to the large amount of scrolling. In the present study this was also true of the slower novices. However, the scrolling behavior was more damaging to performance with a file hierarchy due to the large amount of data that could be scrolled through (2780 lines). In addition, the file hierarchy introduces another organizational structure which novices have to master. The use of ZOOM OUT by slower novices in the present investigation was indicative of the problems they were having with the file hierarchy. Consequently, the performance of slow novices was compounded by not knowing in which file the information is located.

However, the additional hierarchical data structure does not impede the performance of every novice subject. Novices have the capability to understand the organization of the file hierarchy. Indeed, Durding, Becker, and Gould (1977) have illustrated the capability of individuals to conceptualize and use several data structures like lists, networks, tables, and hierarchies to organize data. But as Durding, Becker, and Gould (1977) also point out, individuals sometimes rely entirely on lists to organize data. Thus, the large variability in search performance may be influenced by the conceptual organization created by novices when learning the information retrieval task. The fast novices, like experts, identified the hierarchy quickly and used this knowledge to organize search. Slower novices may not have fully understood the hierarchical organization leading to difficulties in locating the correct file for information retrieval.

However, the conceptual organization hypothesis is one of several hypotheses that need to be tested. Several factors may have contributed to the heterogeneity of novice search performance. For example, some novices in attempting to manipulate all the information required for solution of the search problem may have been limited by spatial memory constraints or their analytical ability. Further research will be required to identify both the characteristics of the task and the characteristics of the users which contribute to the variability in novice search performance.

CONCLUSIONS

The results of these experiments demonstrated that the widely varying search performance of novice subjects could be improved through the use of online command-selection aids. The search commands provided as advice by the online aids provided an active and feedback-rich environment where novices could learn and practice the information retrieval task. With these suggested search procedures slower novices were able to identify and correct inefficient scrolling strategies permitting these subjects to learn and explore the information retrieval database.

The different types of command-selection advice presented by the frequency, sequence, and plan-based models had little effect on search performance. Frequency, sequence, and plan-based models were all equally effective as a training device. Sequence models, however, demonstrated some difficulties with assisting novices due to the complicated and frequent advice offered to the subject. Subjective evaluations verified these difficulties since novices receiving the command-sequence advice evaluated the online aid less favorably than novices receiving the plan-based advice.

In providing this command-selection advice, mixed-initiative dialogues were found to result in poor search performance in the first session of aiding. The poor search performance was only temporary with mixed-initiative dialogues, but large enough to suggest careful implementation of these dialogues when introducing a software interface to a new user. Moreover, the transient nature of the poor search performance indicated that the effect may be due to the self-evaluation required by the user when deciding whether to receive the suggested advice.

These effects of mixed-initiative dialogues were not reflected in the user preference rankings of the three dialogues. Rather, a strong lack of preference for the computer-initiated dialogues was demonstrated with performance-based models (frequency and sequence) probably due to the intrusiveness of the dialogue. The lack of a user preference difference for the plan-based models may argue for the viability of computer-initiated dialogues with planning information since verbal explanations may alleviate some of the psychological intrusiveness of the dialogue.

Thus, not only did this experiment demonstrate the effectiveness of the command-selection aids, the experiment also provided detailed recommendations for the implementation of future command-selection aids.

Command-selection models and associated dialogue-initiatives worthy of future research and development in this information retrieval task are:

1. plan-based models
   a) user-initiated dialogues
   b) computer-initiated dialogues
2. frequency models
   a) user-initiated dialogues

However, these recommendations should not discourage further investigation of other models or dialogues since the knowledge and understanding of advisory and online training systems is just beginning to form.

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Appendix A

INFORMED CONSENT FOR RESEARCH PARTICIPANTS

A LAND-GRANT UNIVERSITY

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Human Factors Laboratory
130 Whittemore Hall

Blacksburg, Virginia 24061

PARTICIPANT'S STATEMENT OF INFORMED CONSENT

You are asked to participate in a study of to investigate how people retrieve computer-based information. The purpose of the study is to provide us information on how to assist and instruct inexperienced computer users. In the experiment you will be asked to retrieve specific information from a hypothetical database. The study will take approximately 10 total hours spread across six sessions on separate days. During some of these sessions you may receive computer-based assistance in retrieving information from the database.

We hope that this experiment will be an interesting experience for you. It is possible that at times you may feel frustrated or stressed. However, your performance only reflects the difficulty of the task.

All information collected in the experiment will be held in strict confidence. We will use the information for statistical and summary purposes only, and will make certain that your name is not associated with your records. To the best of our knowledge, there are no physical or psychological risks associated with the procedures in our study.

As a participant in this study, you have certain rights. These rights will now be explained to you, and you will be asked for your signature, indicating that you consent to participation in this research.

1. You have the right to stop the experiment in which you are participating at any time if you feel that it is not agreeable to you. Should you terminate the experiment, you will receive pay only for the proportion of time you participated.

2. You have the right to see your data and to withdraw it from the experiment if you feel that you should.

3. You have the right to be informed of the results of the overall experiment. If you wish to receive a summary of the results, please indicate your address (three months hence) with your signature. A summary will be sent to you. If you should then like further information, please contact the Human Factors Laboratory and a full report will be made available to you.

4. You have the right to call either Dr. Robert Williges, the principal investigator, at 961-6270 or Mr. Charles Waring, Institutional Review Board Chairman, at 961-5283, with your concerns about any aspect of the experiment.

The faculty and graduate students involved greatly appreciate your help as a participant. If you have any question about the experiment or your rights as a participant, please do not hesitate to ask. We will do our best to answer them, subject only to the constraint that we do not want to pre-bias the experimental results.

Your signature on the back of this form indicates that you have read your rights as a participant as stated above and that you consent to participation. If you include your printed name and address below, a summary of the experimental results will be sent to you.

Appendix B

PORTIONS OF THE INFORMATION RETRIEVAL DATABASE

FILE NUMBER 1

Army Operations

Tank Division

Tank Equipment Statistics (FILE NUMBER 2)

Tank Division Mission

To conduct offensive and defensive operations on a battlefield either independently or as part of a combined arms army.

Tank Division Subgroups

Division Headquarters
Tank Regiments
Motorized Rifle Regiments

Tank Division Combat Support (FILE NUMBER 8)

Tank Division Operational Capabilities

Offense

Attack as a first echelon division of a tank army to penetrate enemy defensive positions
Operate as the exploitation force of a combined arms or tank army to exploit gaps in enemy formations
Attack as a first echelon division of a combined army whenever the enemy is weak and good terrain is available
Conduct pursuit operations, whenever the enemy is withdrawing, to destroy the enemy and secure army objectives

Defense

Conduct mobile counterattack operations from positions within or behind the army's second echelon
Defend in place to gain time to mass forces for continuing an attack

Tank Division Personnel Strengths

Unit	Officers	Enlisted Personnel
Division Headquarters	93	208
Tank Regiments	120	981
Artillery Regiments	98	1033
Mult. Rocket Launcher Battalions	30	491
Anti-Aircraft Gun Regiments	26	302
Reconnaissance Battalions	39	261

FILE NUMBER 2

Tank Equipment Statistics

T-72 Battle Tank

T-72 Tank Inventory and Availability (FILE NUMBER 3)

Specific Characteristics

Crew: Three (commander, gunner, driver)
Weight: 40 tons

Size
Length: 9.02m (gun forwards)
Width: 3.375m
Height: 2.265m

Road speed: 80 km/hr
Road range: 500km

Main armament: 125mm smooth bore gun
Secondary armament: 7.62mm PKT machine gun co-axial with the main armament and a 12.7mm DshK anti-aircraft machine gun.

Method of ranging: Laser rangefinder and an infra-red searchlight.

Ammunition: 40 rounds of 125mm ammunition, 22 HE, 6 HEAT, and 12 APFSDS rounds.

Miscellaneous Characteristics

The T-72 has large road wheels and can be fitted with lightly armored skirting plates to provide a measure of protection against HEAT projectiles. The T-72 can ford to a depth of 1.4m without preparation and when fitted with a snorkel can ford to 5.486m. The engine is a water cooled diesel developing 700hp. This provides the T-72 with the agility to climb gradients of up to 60%. It can also breach a 2.8m trench or climb a 0.81m vertical obstacle.

T-64 Battle Tank

T-64 Tank Inventory and Availability (FILE NUMBER 4)

Specific Characteristics

Crew: Three (commander, gunner, driver)
Weight: 35 tons

Size
Length: 8.0m
Width: 3.375m
Height: 2.25m

Road speed: 60 km/hr

FILE NUMBER 3

T-72 Tank Inventory and Availability

Number of T-72 Tanks

Tank Regiment	Regiment Name	Total Number	Total Available
97	Bravo	20	15
356	Lightning	25	20
567	Grayhawk	19	17
789	Spearhead	17	7
890	Arrow	19	18
1679	Wildcat	15	13

Tank Availability and Maintenance

Bravo Tank Regiment 97

Tank ID	Front Location	Maintenance Battalion	Battle Hours	Maintenance Code
4977	North	Yellow-1	25	Engine
34AA	North	Yellow-1	33	Track
5AKE	North	Yellow-1	45	
13E5	North	Orange-1	4	
491D	North	Yellow-1	14	
2EC8	Northeast	Yellow-1	13	Turret
443F	North	Orange-1	10	
5122	North	Orange-1	6	
49D7	Northeast	Yellow-1	15	Gun
3YAA	Northeast	Orange-1	56	
5A4E	Northeast	Yellow-1	13	
9265	Northeast	Orange-1	14	
4G16	Northeast	Yellow-1	54	
2YC3	Northeast	Yellow-1	43	
345F	Northeast	Orange-1	18	
5T2C	Northeast	Orange-1	7	Track
49D7	Northeast	Orange-1	12	
31AT	North	Orange-1	17	
2A6E	North	Yellow-1	13	
1295	North	Orange-1	4	

Lightning Tank Regiment 356

Tank ID	Front Location	Maintenance Battalion	Battle Hours	Maintenance Code
4358	Northwest	Orange-2	27	
2010	Northwest	Orange-2	40	
64P2	Northwest	Yellow-2	11	
9304	Northwest	Orange-2	16	Loader
7301	Northwest	Orange-2	19	
5617	Northwest	Orange-2	18	Turret
9D78	North	Orange-2	15	

FILE NUMBER 4

T-64 Tank Inventory and Inventory

Number of T-64 Tanks

Tank Regiment	Regiment Name	Total Number	Total Available
45	Charlie	15	10
109	Tower	10	5
345	Bulldog	18	9
629	Bullet	13	8
878	Razor	18	15
1399	Renegade	14	7

Tank Availability and Maintenance

Charlie Tank Regiment 45

Tank ID	Front Location	Maintenance Battalion	Battle Hours	Maintenance Code
3897	South	Yellow-5	15	
140A	South	Yellow-5	49	
5R79	South	Orange-5	40	
13W5	South	Orange-5	1	
4916	South	Yellow-5	19	
2PC8	South	Yellow-5	13	Turret
443F	Southeast	Orange-5	35	Track
5569	Southeast	Orange-5	9	Gun
43D0	Southeast	Orange-5	22	
3Y2A	Southeast	Orange-5	36	
5A4I	On reserve	Yellow-5	10	
T2H5	On reserve	Yellow-5	19	Armor
441P	On reserve	Yellow-5	55	
2YI5	South	Yellow-5	44	Engine
342Q	South	Orange-5	19	

Tower Tank Regiment 109

Tank ID	Front Location	Maintenance Battalion	Battle Hours	Maintenance Code
D258	West	Orange-7	89	
2190	West	Orange-7	10	Loader
24PP	West	Yellow-7	71	
9914	West	Orange-7	91	Loader
7321	West	Orange-7	88	
563F	West	Orange-7	45	Turret
9D71	Southwest	Yellow-7	1	Engine
0235	Southwest	Yellow-7	10	Track
482K	Southwest	Orange-7	35	
7C1R	Southwest	Orange-7	3	

Bulldog Tank Regiment 345

FILE NUMBER 5

T-62 Tank Inventory and Availability

Number of T-62 Tanks

Tank Regiment	Regiment Name	Total Number	Total Available
103	Laser	12	6
221	Alpha	9	9
302	Desert	10	7
721	Scorpion	25	10

Tank Availability and Maintenance

Laser Tank Regiment 103

Tank ID	Front Location	Maintenance Battalion	Battle Hours	Maintenance Code
X082	Northeast	Orange-1	5	Turret
131A	Northeast	Yellow-1	39	
5R69	Northeast	Orange-1	20	Loader
33W8	North	Orange-1	5	
4946	North	Yellow-1	19	
2P12	North	Yellow-1	15	
483F	North	Yellow-1	37	Track
52N9	Northeast	Orange-1	10	Gun
40D0	Northeast	Yellow-1	21	
3Y5A	Northeast	Orange-1	37	Gun
5A41	Northeast	Yellow-1	19	
62H3	Northeast	Yellow-1	13	Armor

Alpha Tank Regiment 221

Tank ID	Front Location	Maintenance Battalion	Battle Hours	Maintenance Code
D258	South	Orange-6	30	
2190	South	Orange-6	20	
24PP	South	Yellow-6	62	
9914	South	Orange-6	63	
7321	South	Yellow-6	25	
563F	West	Orange-6	24	
9D71	West	Yellow-6	5	
0235	West	Orange-6	15	
482K	West	Orange-6	22	

Desert Tank Regiment 302

Tank ID	Front Location	Maintenance Battalion	Battle Hours	Maintenance Code
1DYL	South	Yellow-5	45	
2BT1	South	Yellow-5	72	Track

FILE NUMBER 6

T-10 Tank Inventory and Availability

Number of T-10 Tanks

Tank Regiment	Regiment Name	Total Number	Total Available
23	Hammer	10	5
723	Bear	10	7
1826	Victory	5	4

Tank Availability and Maintenance

Hammer Tank Regiment 23

Tank ID	Front Location	Maintenance Battalion	Battle Hours	Maintenance Code
13Y1	On reserve	Yellow-5	10	Turret
349A	On reserve	Orange-5	28	Track
7369	On reserve	Orange-5	27	Turret
33U8	On reserve	Orange-5	10	
5946	On reserve	Yellow-5	1	Loader
2342	Southeast	Yellow-5	10	
4YSF	Southeast	Yellow-5	23	
8MN9	Southeast	Yellow-5	39	Gun
10DW	Southeast	Yellow-5	20	
3T5A	Southeast	Orange-5	33	

Bear Tank Regiment 723

Tank ID	Front Location	Maintenance Battalion	Battle Hours	Maintenance Code
821L	South	Orange-8	33	
2721	South	Orange-8	43	Loader
1357	Southeast	Yellow-8	81	
5KP3	Southeast	Orange-8	24	
21F6	Southeast	Orange-8	1	
2SC7	Southeast	Yellow-8	42	
343X	On reserve	Yellow-8	45	
1490	On reserve	Yellow-8	23	Track
5440	On reserve	Orange-8	21	Turret
5544	On reserve	Yellow-8	22	

Victory Tank Regiment 1826

Tank ID	Front Location	Maintenance Battalion	Battle Hours	Maintenance Code
1T26	North	Orange-4	37	
48P0	North	Yellow-4	38	
2EL2	North	Orange-4	32	
8E23	Northeast	Orange-4	17	Turret

FILE NUMBER 7

PT-76 Tank Inventory and Availability

Number of PT-76 Tanks

Tank Regiment	Regiment Name	Total Number	Total Available
56	Aqua	25	18
178	Neptune	22	20
358	Delta	30	25
985	River	20	10
1093	Seal	15	9

Tank Availability and Maintenance

Aqua Tank Regiment 56

Tank ID	Front Location	Maintenance Battalion	Battle Hours	Maintenance Code
155U	South	Green-3	15	
8922	South	Green-3	25	Turret
1G90	South	Blue-3	23	
5E89	South	Green-3	43	Loader
58Y2	South	Blue-3	1	
783P	On reserve	Green-3	14	Turret
3902	On reserve	Blue-3	9	
4828	On reserve	Blue-3	20	
39S3	On reserve	Green-3	15	
4W0I	On reserve	Blue-3	16	
394A	On reserve	Green-3	53	
5931	Southwest	Blue-3	62	
1T49	Southwest	Blue-3	29	
2032	Southwest	Green-3	4	Turret
2902	Southwest	Blue-3	56	
0P98	Southwest	Green-3	37	
9458	Southwest	Green-3	34	
2Q03	Southwest	Green-3	67	Waterjet
19K0	North	Blue-1	53	
490F	North	Blue-1	34	
5902	Northeast	Blue-1	27	Gun
43F5	Northeast	Green-1	38	
9345	Northeast	Green-1	37	Gun
2590	Northeast	Green-1	21	
2I50	Northeast	Green-1	18	

Neptune Tank Regiment 178

Tank ID	Front Location	Maintenance Battalion	Battle Hours	Maintenance Code
92N8	Southeast	Green-2	31	
29S3	Southeast	Green-2	25	
8D43	Southeast	Blue-2	36	

FILE NUMBER 8

Tank Division Combat Support

Artillery Regiment

Artillery Regiment Mission

Provide fire support to the tank divisions making a main advance

Artillery Regiment Subgroups

Headquarters
Artillery Units
Anti-Tank Battalions
Motor Transport Battalions
Target Acquisition Units

Artillery Regiment Operational Capabilities

Deliver preparatory fires to support the offensive
Engage anti-tank defenses
Deliver fire on infantry strong points
Deliver smoke cover on enemy observation points
Deliver illumination and marking rounds in night operations for friendly directional control
Deliver harassing and interdicting fire on enemy routes of reinforcement and withdrawal

Multiple Rocket Launcher Battalion

Multiple Rocket Launcher Battalion Mission

To provide a multi-barreled rocket launcher capability in support of division operations

Multiple Rocket Launcher Battalion Subgroups

Headquarters
Firing Battery
Service Battery

Multiple Rocket Launcher Battalion Operational Capabilities

Provide heavy weight of fire on important targets at decisive moments in an engagement
Provide a rapid fire capability
Provide counter-bombardment

Anti-Aircraft Gun Regiment

Anti-Aircraft Gun Regiment Mission

Provide close-in air defense protection to the division by engaging targets at maximum operational ranges during offensive and defensive operations

FILE NUMBER 9

Motorized Rifle Equipment Statistics

BMP-1 Armored Personnel Carrier

BMP-1 Inventory and Availability (FILE NUMBER 10)

Specific Characteristics

Crew: 11 (Commander, gunner, driver plus 8 infantrymen)
Weight: 12.5 tons

Size
Length: 6.75m
Width: 3.0m
Height: 2.0m

Road speed: 55 km/hr
Road range: 500km

Main armament: 73mm low pressure gun
Secondary armament: 7.62mm PKT machine gun co-axial with the main armament

Method of ranging: Visual and infra-red searchlight

Ammunition: 28 HEAT rounds

Miscellaneous Characteristics

The BMP-1 is designed to accompany tanks into the assault and right on to and beyond the objective. Although the the BMP-1 is an amphibian, it does not employ hydrojets, but obtains its propulsion in water from the the tracks. Exits for the infantry section is through two rear doors, which have fuel tanks incorporated. The combination of effective anti-armor fire power, high mobility, and adequate protection makes the BMP-1 an formidable enemy.

BTR-60 Armored Personnel Carrier

BTR-60 Inventory and Availability (FILE NUMBER 11)

Specific Characteristics

Crew: 12 (Driver, commander plus 10 infantrymen)
Weight: 10 tons

Size
Length: 7.56m
Width: 2.82m
Height: 2.31m

Road speed: 80 km/hr
Road range: 500km

FILE NUMBER 10

BMP-1 Armored Personnel Carrier (APC) Inventory

Number of BMP-1 APCs

APC Regiment	Regiment Name	Total Number	Total Available
25	Sahara	40	32
278	Prairie	53	47
892	Harrow	85	56
931	Zulu	45	21

APC Availability and Maintenance

Sahara APC Regiment 25

APC ID	Front Location	Maintenance Battalion	Battle Hours	Maintenance Code
4B675	Northwest	Orange-2	78	Track
8847C	Northwest	Orange-2	85	
BBB63	Northwest	Yellow-2	65	
CA819	Northwest	Orange-2	24	Fuel
918D4	Northwest	Yellow-2	124	
DC623	Northwest	Yellow-2	10	
854A8	Northwest	Yellow-2	170	
8E477	North	Yellow-2	147	
D61BF	North	Orange-2	13	
BC1DA	North	Yellow-2	75	Track
6CBA1	North	Yellow-2	35	
99F14	North	Orange-2	75	
327E7	North	Yellow-2	101	
98137	North	Yellow-2	157	Hydrojet
B5C15	North	Yellow-2	199	
6F395	North	Yellow-2	35	
E1B3	North	Yellow-2	2	
5E0C3	North	Yellow-2	54	
ABCBF	West	Green-2	140	Fuel
1101F	West	Green-2	11	
B6DA2	West	Green-2	105	
ECE5E	North	Yellow-2	47	
C396	North	Yellow-2	195	Track
DC944	North	Yellow-2	20	
1CCAC	North	Orange-2	115	
8B269	North	Orange-2	2	
6B609	North	Orange-2	151	
80FA3	North	Orange-2	161	
598D5	North	Orange-2	191	Gun
5AD68	West	Green-2	125	Gun
DD4E9	West	Green-2	57	
6E8D0	West	Green-2	132	
69024	West	Green-2	11	
A082E	West	Green-2	64	
3223E	West	Yellow-2	41	

FILE NUMBER 11

BTR-60 Armored Personnel Carrier (APC) Inventory

Number of BTR-60 APCs

APC Regiment	Regiment Name	Total Number	Total Available
102	Forest	34	30
472	Thunder	46	35
499	Tiger	39	35
505	Echo	40	26
634	Sierra	53	45

APC Availability and Maintenance

Forest APC Regiment 102

APC ID	Front Location	Maintenance Battalion	Battle Hours	Maintenance Code
7D4C2	On reserve	Orange-1	19	
272AE	On reserve	Orange-1	44	
1CF92	On reserve	Orange-1	95	
B9A7E	On reserve	Orange-1	149	Hydrojet
4AAE3	On reserve	Yellow-4	88	
30FA0	Northeast	Yellow-4	125	
A7EB6	Northeast	Yellow-4	59	
117DF	Northeast	Yellow-4	78	
E4A32	North	Yellow-4	59	
2F57	North	Blue-4	82	
3BE7E	North	Blue-4	134	
A006D	North	Blue-4	162	
90550	North	Blue-1	133	
AEF2D	North	Blue-1	89	
9C067	North	Blue-1	13	Armor
1E7A	Northeast	Yellow-1	12	
CF05D	Northeast	Yellow-1	125	
9DA1D	Northeast	Yellow-1	50	
22AB	Northeast	Yellow-1	41	
662C9	Northeast	Yellow-1	154	
8B526	Northeast	Yellow-1	76	
B4EF7	Southeast	Yellow-1	100	
C49CA	Southeast	Yellow-1	10	Engine
5C21F	North	Yellow-1	144	Fuel
D6C06	Southeast	Yellow-1	45	
9D925	Southeast	Yellow-4	95	
AB82C	Southeast	Yellow-4	30	
39E6B	Southeast	Orange-1	161	
7B768	Southeast	Orange-1	41	
8BBE3	Southeast	Orange-1	77	
D3048	On reserve	Blue-1	11	
958C2	On reserve	Blue-1	153	
50DF5	On reserve	Blue-1	149	
9539A	On reserve	Blue-1	126	

FILE NUMBER 12

BTR-50P Armored Personnel Carrier (APC) Inventory

Number of BTR-50P APCs

APC Regiment	Regiment Name	Total Number	Total Available
12	Caspian	46	37
243	Oscar	49	45
452	Titan	55	45
531	Marauder	43	37
634	Silent	50	49
1983	Crater	59	59

APC Availability and Maintenance

Caspian APC Regiment 12

APC ID	Front Location	Maintenance Battalion	Battle Hours	Maintenance Code
5931	East	Orange-3	282	
E0113	East	Orange-3	109	Cooling
8C841	East	Orange-3	192	
74C5B	East	Orange-8	190	
23CB9	East	Orange-8	170	
9943	East	Orange-8	70	
D2C16	East	Orange-8	97	Engine
D7143	On reserve	Orange-8	237	Engine
9C65E	On reserve	Orange-8	63	
4B6F7	On reserve	Blue-5	217	
72574	On reserve	Blue-5	71	
4CB65	On reserve	Blue-5	153	
34037	On reserve	Blue-5	205	
CAD5B	Southeast	Blue-5	311	
6715A	Southeast	Orange-8	317	Gun
89253	Southeast	Orange-8	307	Fuel
EAB17	Southeast	Orange-8	241	
32B21	Southeast	Orange-3	150	
6E5C2	Southeast	Orange-3	48	
BCED9	Southeast	Orange-3	161	
4B124	Southeast	Orange-3	179	
A9BDE	Southeast	Orange-8	109	
892EC	On reserve	Orange-8	261	Fuel
19032	On reserve	Orange-8	170	
4E93	On reserve	Orange-8	268	
C3BFC	On reserve	Orange-8	260	
99752	West	Orange-8	169	
4F6C8	West	Orange-8	306	
9CF0D	West	Orange-8	314	
2479A	West	Orange-8	116	Hydrojet
47C93	West	Orange-8	255	
EF0D7	West	Orange-3	152	
D8C64	West	Orange-3	305	

FILE NUMBER 13

BTR-152 Armored Personnel Carrier (APC) Inventory

Number of BTR-152 APCs

APC Regiment	Regiment Name	Total Number	Total Available
143	Ranger	20	9
780	Lion	25	14
854	Taurus	15	11
929	Leopard	10	5

APC Availability and Maintenance

Ranger APC Regiment 143

APC ID	Front Location	Maintenance Battalion	Battle Hours	Maintenance Code
6784	South	Yellow-7	42	
67244	South	Yellow-7	7	
3A219	South	Yellow-7	13	Armor
85FCD	South	Yellow-7	15	Fuel
1873F	South	Yellow-7	42	
215AB	Southeast	Yellow-7	20	Wheel
B588E	Southeast	Orange-2	9	
B2208	East	Yellow-7	47	
AFE42	East	Orange-2	38	
9767C	East	Orange-2	50	
68A62	East	Yellow-7	67	
18682	On reserve	Orange-2	44	Engine
EA4A6	On reserve	Orange-2	41	Engine
CA01F	On reserve	Orange-2	57	Armor
DC888	On reserve	Orange-2	14	Engine
D6D70	On reserve	Yellow-7	3	Fuel
D742F	On reserve	Orange-2	37	Wheel
BF8B3	On reserve	Orange-2	48	
D576E	On reserve	Orange-2	59	
6E692	On reserve	Orange-2	21	Wheel

Lion APC Regiment 780

APC ID	Front Location	Maintenance Battalion	Battle Hours	Maintenance Code
E3CFC	Southeast	Blue-1	63	
ECB33	Southeast	Blue-1	64	Armor
434DD	Southeast	Yellow-7	9	
4AC94	Southeast	Blue-1	60	
80D8A	Southeast	Blue-1	69	
9EF13	On reserve	Blue-1	64	Engine
CA2F8	On reserve	Blue-1	22	Engine
71C86	On reserve	Orange-4	54	
835E1	On reserve	Orange-4	34	Engine

FILE NUMBER 14

MT-LB Multipurpose Tracked Vehicle (MTV) Inventory

Number of MT-LB MTVs

MTV Regiment	Regiment Name	Total Number	Total Available
108	Bison	49	46
361	Gray	53	50
571	Rover	45	43
780	Cheetah	42	41
853	Foxtrot	45	40
1276	Whiskey	50	45
1852	Xenon	52	49
1871	Pelican	46	40

MTV Availability and Maintenance

Bison MTV Regiment 108

MTV ID	Front Location	Maintenance Battalion	Battle Hours	Maintenance Code
845EF5	East	Green-2	164	
73FD59	East	Green-2	308	
50BF32	East	Green-2	114	
8CDA2B	East	Green-2	281	
22C7AF	East	Green-2	198	
4FBD4B	East	Green-2	102	Armor
22FF50	East	Green-2	162	
6ACED8	East	Green-2	313	
6392B5	East	Green-2	133	
196054	East	Green-2	118	
51077A	East	Green-2	103	
80205	East	Green-2	68	
EDE7F	East	Green-2	297	
1F5AD4	East	Green-2	237	
862FF5	East	Green-2	7	
75FDE5	East	Green-2	53	Gun
1F398E	East	Green-2	350	
3F1F7A	East	Green-2	55	
551D46	East	Green-2	63	
396C31	East	Green-2	384	
DEF28	East	Green-2	331	Engine
8E85F2	East	Green-2	226	
37AD67	Southeast	Green-2	392	
45C3BE	Southeast	Green-2	3	
51DE0C	Southeast	Green-2	318	
8D1715	Southeast	Green-2	179	
6A9958	Southeast	Green-2	102	
390AF4	Southeast	Green-2	250	
9BF50	Southeast	Green-2	132	
938B6B	Southeast	Green-2	153	
269598	Southeast	Green-2	233	

FILE NUMBER 15

Motorized Rifle Division Combat Support

Direct Combat Support

Artillery Regiment

Artillery Regiment Mission

Provide fire support to the motorized rifle divisions making a main advance
Assist in the defense of critical areas

Artillery Regiment Subgroups

Headquarters
Artillery Units
Target Acquisition Units

Artillery Regiment Operational Capabilities

Deliver preparatory fires to support offensive
Suppress enemy artillery
Deliver fire on infantry strong points
Deliver fire on enemy tactical reserves
Deliver smoke cover on enemy observation points
Deliver illumination and marking rounds in night operations for friendly directional control
Deliver harassing and interdicting fire on enemy routes of reinforcement and withdrawal
Engage targets of opportunity
Destroy major supply depots and communications in rear areas

Anti-Tank Missile Battalion

Anti-Tank Missile Battalion Mission

To provide anti-tank support to motorized rifle forces as the nucleus of the anti-tank reserve

Anti-Tank Missile Battalion Subgroups

Headquarters
Anti-Tank Missile Battery
Supply and Maintenance Company

Anti-Tank Missile Battalion Operational Capabilities

Offense

Move behind the advancing first echelon tanks and infantry on the most exposed line of advance, ready to cover the deployment of enemy attacking units and to repel armor counterattacks
Cover the flanks

Appendix C

RECOGNITION TEST FOR THE DATABASE

1. Which of the following is a subfile of Tank Equipment Statistics?

   a. BTR-60 Inventory and Availability
   b. Artillery Equipment Statistics
   c. PT-76 Inventory and Availability
   d. Tank Division Combat Support
   e. F-139 Inventory and Availability

2. What file would a maintenance battalion, maintenance code and number of battle hours be listed in?

   a. Armored Vehicle Equipment Statistics
   b. Tank Equipment Statistics
   c. BMP-1 Inventory and Availability
   d. Army Operations
   e. Tank Division Combat Support

3. Where besides the Army Operations file will operational capabilities be found?

   a. Tank Division Combat Support
   b. Tank Equipment Statistics
   c. FT-21 Inventory and Availability
   d. Anti-Aircraft Inventory and Availability
   e. PT-76 Inventory and Availability

4. Which of the following files is one file below the Army Operations in the file hierarchy?

   a. Multiple Rocket Launcher Equipment
   b. SBT-132 Inventory and Availability
   c. Tank Division Combat Support
   d. PT-76 Inventory and Availability
   e. T-62 Inventory and Availability

5. Information on crew size is contained in:

   a. Motorized Rifle Equipment Statistics
   b. Tank Division Combat Support
   c. BTR-50P Inventory and Availability
   d. Army Operations
   e. Surface to Air Missile Inventory

6. What file has information on armored personnel carriers?

   a. Motorized Rifle Division Combat Support
   b. Motorized Rifle Equipment Statistics
   c. Tank Equipment Statistics
   d. Armored Vehicle Equipment Statistics

7. Regiment names and ID codes would be located in:

   a. BMP-1 Inventory and Availability
   b. Armored Vehicle Equipment Statistics
   c. Army Operations
   d. Tank Division Combat Support

8. In which of the following files is front information is NOT listed?

   a. BMP-1 Inventory and Availability
   b. Tank Equipment Statistics
   c. T-62 Inventory and Availability
   d. BTR-152 Inventory and Availability

9. A code like Green-7 indicates a:

   a. Tank regiment
   b. Maintenance battalion
   c. Front location
   d. Division subgroup
   e. Ammunition type

10. Information on the total number of officers is contained in which of the following files?

    a. Tank Division Combat Support
    b. Motorized Rifle Division Combat Support
    c. Army Operations
    d. F-10 Inventory and Availability
    e. T-62 Inventory and Availability

11. Battle hours is included in which of the following files?

    a. Artillery Equipment Statistics
    b. Army Operations
    c. Tank Division Combat Support
    d. Motorized Rifle Division Combat Support
    e. T-72 Inventory and Availability

12. Information on offensive and defensive operational capabilities is NOT contained in:

    a. T-10 Inventory and Availability
    b. Army Operations
    c. Tank Division Combat Support
    d. Motorized Rifle Division Combat Support

13. Information on subgroups and mission CANNOT be found in:

    a. Tank Division Combat Support
    b. Motorized Rifle Division Combat Support
    c. Army Operations
    d. BTR-50P Inventory and Availability

14. The MT-LB Inventory and Availability file would be a subfile of:

    a. Motorized Rifle Equipment Statistics
    b. Artillery Equipment
    c. Army Operations
    d. Armored Vehicle Equipment Statistics
    e. SBT-132 Inventory and Availability

Appendix D

INTRODUCTORY INSTRUCTIONS

Welcome to the Information Retrieval Assistance Study.

I am the DECtalk, and you will be listening to me during the training phase of the experiment.

The purpose of this study is to investigate the methods and procedures that experienced and inexperienced people use in information retrieval so that we can construct systems that assist inexperienced users in these tasks.

Therefore, over the next 6 sessions you will be asked to learn and use an information retrieval system that has data on a hypothetical enemy. As Jay has probably already told you, today is probably the longest session since familiarization and training on the procedures of the experiment must be completed.

This training session will probably last 2 to 3 hours. The next 5 sessions will probably last 1 to 2 hours. In these last 5 sessions, you will be asked to locate information in an information retrieval database. In all of these sessions, you will be given breaks to avoid any unnecessary fatigue.

The tasks and procedures that we are asking you to perform may not be easy. However, we hope that you attempt to perform these activities as best you can. Throughout the experiment we would like you to locate the information as quickly as possible.

Please feel free to ask questions during the experiment. This is especially critical today, since you will be taught a significant amount of new information and it is impossible to explain everything clearly. We will try our best to answer these questions, subject only to the constraint that we do not want to bias the results.

Two things will be covered today. First, you will be trained and familiarized with the information retrieval database. Second, you will be trained and practice the search procedures individually in the information retrieval system.

The second session will be the final day of practice before the start of the experiment. In this session, you will first review the database and search procedures. Then we will ask you to locate information using all the search procedures. This will give you practice integrating the knowledge and skills you learned on the first day.

At the end of this second session, a comprehension test will be given to determine your knowledge and understanding of the database. From this test, and a measure of your speed of finding information, a decision will be made whether you can continue in the experiment.

If you do not continue, you will receive payment for the proportion of time you participated.

At this time, please ask the experimenter to start you on the information retrieval database.

Appendix E

TUTORIAL FOR THE INFORMATION RETRIEVAL DATABASE

Information Retrieval Database

The information retrieval database is a large set of structured files that contain data on the operations and equipment of a hypothetical enemy. If the military nature of this database offends you, we would like to apologize.

However, the data that we collect from this study is not pointed towards any specific military system. Rather the military database was chosen to be representative of the complexities of several online retrieval systems. In other words, our results are focused on acquiring basic knowledge for the design of human-computer systems, in general, and information retrieval systems, specifically.

Two pieces of information to your left will be used in this training exercise. First, there is a large single piece of paper which contains a map of the information retrieval database. Second, there is a 3-ring notebook which contains the actual database.

Lets take a look at the map of the information retrieval database. The first thing you should know about this map is that each box in this hierarchy represents a file. In each box is a label for the information that is contained in the file.

Therefore, the information retrieval database consists of an hierarchy of 15 files. These files are divided into two major divisions: those files dealing with the Tank Division, and those files dealing with the Motorized Rifle Division.

We will be reviewing each of the 15 files briefly to give you a familiarity with the file hierarchy. Please pay close attention to this review since your continuation in this study requires that you understand both the structure and some content of the database.

In fact, as was explained earlier you will be given a comprehension test at the end of the second day of the experiment. In this test, we will ask you to recognize important aspects of the database.

However, you should not become overly concerned with this test or the large amount of information. In this training session, we will identify the important information that you will need to know. The rest of the information you can just scan quickly.

The order in which we will review the files in the file hierarchy will be by the red numbers listed above the upper right hand corner of each box in the map. This number corresponds to the file number in the tabs of the notebook, and the file number in the upper right hand corner of each page in the notebook.

Please use both the map and the notebook in reviewing this database.

File Number 1: Army Operations

The first file we will review is the main Army Operations file. This is the top file of the hierarchy and will serve as the starting point in retrieval.

A point to note about this file and all other files is the section numbering used to indicate the internal file structure. Each file has has an internal hierarchy that will be used by the information retrieval software to present a table of contents.

However, the section numbers will not be displayed in the computerized version of these files. Therefore, it is important to browse these lines so that you are familiar with the internal file hierarchy.

For example, the important sections of the Army Operations file consist of information on the:

1. Tank Division, (Section 1.1)
2. Motorized Rifle Division (Section 1.2).

Each of these sections has information in this file on:

1. equipment statistics,
2. mission,
3. subgroups,
4. combat support,

5. operational capabilities,
6. personnel strengths.

Please browse over the Army Operations file and note these sections.

In addition, with file number 1 you should also note the correspondence between the highlighted lines and the map of the file hierarchy. Each of the highlighted lines in the file corresponds to one of the files in the hierarchy. You can identify the match between the highlighted line and the file in the hierarchy by the section or file number.

The section number of the highlighted line identifies where this line is found in the current file. The file number in the "(TO FILE NUMBER #)" statement identifies the file where additional information can be found.

So, as can be seen through the map and the highlighted lines of the Army Operations file, the subfiles for this main file are:

1. Tank Equipment Statistics (Section 1.1.1),
2. Tank Division Combat Support (Section 1.1.4),
3. Motorized Rifle Equipment Statistics (Section 1.2.1),
4. Motorized Rifle Division Combat Support (Section 1.2.4).

In addition, the file numbers to the right of each of these highlighted lines indicates that:

1. Tank Equipment Statistics can be found in file number 2.
2. Tank Division Combat Support can be found in file number 8.
3. Motorized Rifle Equipment Statistics can be found in file number 9.
4. Motorized Rifle Division Combat Support can be found in file number 15.

Please take another look at the Army Operations file (number 1).

File Number 2: Tank Equipment Statistics

This file includes specific and miscellaneous information on the following tanks:

1. T-72 Battle Tank (Section 1.1.1.1),
2. T-64 Battle Tank (Section 1.1.1.2),

3. T-62 Battle Tank (Section 1.1.1.3),
4. T-10 Heavy Tank (Section 1.1.1.4),
5. PT-76 Amphibious Tank (Section 1.1.1.5).

On each of these tanks the specific characteristics listed are:

1. Crew,
2. Weight,
3. Size,
4. Road speed and range,
5. Armament,
6. Method of ranging,
7. Ammunition.

Notice that this file, and every subsequent file, lists where the current file is referenced. In this case, file number 2 was referenced by file number 1.

In addition, notice that the highlighted lines in Tank Equipment Statistics (file number 2) access subfiles associated with the availability and inventories of each type of tank.

That is to say the T-72, T-64, T-62, T-10, and PT-76 Tank Inventories and Availabilities are contained in file numbers 3, 4, 5, 6, and 7, respectively.

Please take another look at the Tank Equipment Statistics file (number 2).

File Numbers 3 - 7: Tank Inventory and Availability

These files contain information about the availability and inventories of each tank listed in Tank Equipment Statistics (file number 2).

At the top of each of these files is a section containing information about the total number of tanks and the number that are available according to tank regiment.

Please take a few moments and find this section in files 3 - 7.

Following this top section in each file, an individual section for each tank regiment is listed with availability and maintenance information on:

1. Tank ID code,
2. Front location,
3. Maintenance battalion code,

4. Number of battle hours,
5. A maintenance code.

Please take a few moments and look through files 3 - 7 to identify this information and review possible values.

File Number 8: Tank Division Combat Support

This file contains information on regiments and battalions that support the Tank Division in combat. The units listed in this file are:

1. Artillery Regiment (Section 1.1.4.1),
2. Multiple Rocket Launcher Battalion (Section 1.1.4.2),
3. Anti-Aircraft Gun Regiment (Section 1.1.4.3),
4. Reconnaissance Battalion (Section 1.1.4.4).

Each of these sections have information in this file on:

1. Mission,
2. Subgroups,
3. Operational capabilities,

Please take a few moments and browse the Tank Division Combat Support file.

You should note that this Tank Division Combat Support file (number 8) contains verbal material much like the Army Operations file (number 1). This information is much different than the statistics and tabled data on tank equipment and inventory (files 2 - 7).

File Number 9: Motorized Rifle Equipment Statistics

This file includes specific and miscellaneous information on the following armored personnel carriers (APCs):

1. BMP-1 Armored Personnel Carrier (Section 1.2.1.1),
2. BTR-60 Armored Personnel Carrier (Section 1.2.1.2),
3. BTR-50P Armored Personnel Carrier (Section 1.2.1.3),
4. BTR-152 Armored Personnel Carrier (Section 1.2.1.4),
5. MT-LB Multipurpose Tracked Vehicle (Section 1.2.1.5).

On each of these armored personnel carriers the specific characteristics that may be included are:

1. Crew,
2. Weight,
3. Size,

4. Road speed and range,
5. Armament,
6. Method of ranging,
7. Ammunition.

In addition, notice that the highlighted lines in the Motorized Rifle Equipment Statistics file access subfiles associated with the availability and inventories of each type of armored personnel carrier.

Please take a few moments and look over the Motorized Rifle Equipment Statistics file (number 9).

You should note that this Motorized Rifle Equipment Statistics file (file number 9) is structured and contains similar information to that of the Tank Equipment Statistics file (number 2).

File Numbers 10 - 14: Armored Personnel Carrier Inventory and Availability

These files contain information about the availability and inventories of each armored personnel carrier listed in Motorized Rifle Equipment Statistics (file number 9).

At the top of each of these files is a section containing information about the total number of armored personnel carriers and the number that are available according to regiment.

Please take a few moments and find this section in files 10 - 14.

Following this top section in each file, an individual section for each motorized rifle regiment is listed with availability and maintenance information on:

1. Armored personnel carrier (APC) or multipurpose tracked vehicle (MTV) ID code,
2. Front location,
3. Maintenance battalion code,
4. Number of battle hours,
5. A maintenance code.

Please take a few moments and look through files 10 - 14 to identify this information and review possible values.

You should note that these Motorized Rifle Inventory files are structured and contain similar tabular information when compared to the Tank Inventory files (numbers 3 - 7).

File Number 15: Motorized Rifle Division Combat Support

This file contains information on regiments and battalions that support the Motorized Rifle Division in combat. The units listed in this file are divided into those that provide direct combat support and those that provide combat service support.

The Motorized Rifle regiments and battalions that provide direct combat support are the:

1. Artillery Regiment (Section 1.2.4.1.1),
2. Anti-tank Missile Battalion (Section 1.2.4.1.2),
3. Surface to Air Missile Regiment (Section 1.2.4.1.3),
4. Signal Battalion (Section 1.2.4.1.4),
5. Engineer Battalion (Section 1.2.4.1.5).

Please take a moment and locate these sections in the Motorized Rifle Combat Support file.

The Motorized Rifle Battalions that provide combat service support support are the:

1. Maintenance Battalion (Section 1.2.4.2.1),
2. Medical Battalion (Section 1.2.4.2.2),
3. Motor Transport Battalion (Section 1.2.4.2.3).

Please take a moment and locate these sections in the Motorized Rifle Combat Support file (number 15).

Much like the Army Operations file (number 1) and the Tank Division Combat Support file (number 8), all sections of this file have information on:

1. Mission,
2. Subgroups,
3. Operational capabilities.

Please take another look and locate these sections in the Motorized Rifle Combat Support file (number 15).

You have completed the training on the information retrieval database. Please take a 5 minute break.

Appendix F

TUTORIAL FOR THE INFORMATION RETRIEVAL SOFTWARE

Information Retrieval Training

The purpose of this training session is to familiarize you with the basic procedures of the experiment. In this first training session you will be introduced to:

1. the primary and secondary displays,
2. the touch keypad,
3. the information retrieval task,
4. target location.

If you have any questions during this training session, please do not hesitate to ask the experimenter.

Primary and Secondary Displays

The experiment will use two CRT screens. The first CRT screen to the right is the primary display and will be used for presenting the information retrieval system. The second CRT screen to the right is the secondary display and will be used for presenting target information to you.

The primary display contains the information retrieval environment. This information retrieval display has several important areas in it. Of major importance is the 7-line window which is defined by two horizontal lines. This 7-line window is used to display the different computer files in the information retrieval system.

Associated with the 7-line window are line numbers which are presented to the left of the computer file. You will have to refer to these line numbers when you locate a target in a file.

Directly above the 7-line window, is a line that displays the name and length of the current computer file. As can be seen, the current file is called Army Operations and is 100 lines long.

The line below the 7-line window is an input and message line. If a search procedure requires input, the data you enter will be displayed there. In addition, messages will be displayed in the input area when you use the search procedures.

On the lower portion of the primary display is the touch keypad and the work area. The touch keypad is used for selecting search procedures and will be described in the next section of instructions. The work area on the lower left hand side of the primary display will be used to display information associated with specific search procedures.

You will select search procedures on the keypad displayed in the lower right hand corner of the primary display, much like you have been doing on this display when asking for more information. Touching a key will activate a search procedure. This input device is known as a touch panel.

This specific touch panel uses horizontal and vertical light emitting diodes to direct infra-red light beams across the surface of the primary display. When a horizontal and vertical beam are broken the touch panel sends a code to the computer indicating the search procedure you selected.

At the present time, the touch keypad is not working. However, soon you will be given practice using it for search procedure selection.

Information Retrieval

As described earlier, this system is a information retrieval environment with files arranged hierarchically. At the start of every trial you will be positioned at the top file in the hierarchy.

This can be seen on the primary display. The top file in the hierarchy is the Army Operations file. This file contains general information about a hypothetical enemy and highlighted lines where more specific enemy data can be retrieved.

For example, the primary display currently contains the highlighted line: Tank Equipment Statistics. This indicates that more information can be retrieved on tank equipment. The search procedures for accessing this information will be explained later.

During training and practice trials, it may be useful to use the map of the file hierarchy that was provided earlier. This map will be available on all training and practice trials. However, it will not be available during the actual experiment. Therefore, do not rely upon it as an aid, but as a training device for learning the file hierarchy.

Target Location

On each trial in this experiment, you will be asked to find specific information. This information will be shown on the secondary display.

Once you have located the target information using the search procedures on the primary display, you should press the TARGET key. This key is located on the keyboard of the primary display. The computer will then then prompt you to enter the line number of the target. The prompt "Target line number:" will appear on the input and message line.

The line number of the target should then be typed using the digit keys on the main keyboard. Then the RETURN key must be pressed to enter your response.

At this time please enter the target number shown on the secondary display by:

1. Pressing the TARGET key,
2. Typing the line number with the digit keys,
3. Pressing the RETURN key.

All of these keys are on the primary keyboard.

If you have any questions please ask the experimenter.

If not lets start learning the search procedures.

As an aid to learning and using these search procedures, a short reference sheet on the methods for search procedure use is available now and throughout the experiment.

SCROLL UP AND DOWN

The scroll up and down procedures move the lines of the computer file one by one through the 7-line window. The SCROLL keys are located at the top of the touch keypad. Pressing either of the two SCROLL keys will move the lines of the computer file continuously through the display window. For example, when the SCROLL DOWN key is pressed, the movement will be toward the last line in the file.

At this time, please use the SCROLL UP and SCROLL DOWN procedures to find the target displayed on the secondary display. You will have two trials to practice SCROLL UP and DOWN.

(Practice 1: Locate the number of officers in a tank regiment.
Practice 2: Verify that the tank division will conduct pursuit operations against a withdrawing enemy.)

Now lets learn about the page procedures.

PAGE UP AND DOWN

The Page Up and Page Down procedures display consecutive segments of the computer file in the 7-line window. The Page procedure is selected by pressing either the PAGE UP or PAGE DOWN keys, located at the top of the touch keypad.

The PAGE UP key displays the next segment of the computer file moving towards the first line in the file. The PAGE DOWN key displays the next segment of the computer file moving towards the last line in the file.

At this time, please use the PAGE UP and PAGE DOWN procedures to find the target displayed on the secondary display. You will have two practice PAGE UP and PAGE DOWN.

(Practice 1: Locate the number of officers at the division headquarters of the motorized rifle division.
Practice 2: Locate the number of enlisted personnel in an anti-tank missile battalion.)

Now lets learn about the Section procedure.

SECTION

The Section procedure can be used to take advantage of the hierarchical nature of each computer file. That is, the Section procedure will display a table of contents for the current computer file.

To use the Section procedure, touch the SECTION key on the second line of the touch keypad. The prompt "Section number:" will then be displayed on the input and message line. In addition, the major sections of the current file will be shown in the work area of the primary display.

A section can be typed at this point with the digit keys at the top of the primary keyboard. If the RETURN key is then pressed, the Section procedure will position the display window at the line where the section begins.

A summary of these procedures for positioning the display window to a major section in a file is:

1. Touch SECTION on the touch keypad,
2. Select and type the section number with the digit keys on the primary keyboard,
3. Press RETURN on the primary keyboard.

At this time, please try the Section procedure to position the Army Operations file to the section on the "Motorized Rifle Division". When you locate this line please enter its line number with the TARGET key. If you have any difficulties, please ask the experimenter for help.

In addition to the major sections that can be displayed with the Section procedure, this search procedure can also be used to present specific subsections of a computer file.

To select and display subsections, the SECTION key must be touched and a major section number typed that has subsections available. To check to see if any subsections are available, simply look for a "*" by the section number.

To present these subsections you must touch the SECTION key again. Finally, the subsection is selected by typing the subsection number and pressing the RETURN key.

A summary of these procedures for positioning the display window to a subsection in a file is:

1. Touch SECTION on the touch keypad,
2. Select and type the section number that have subsections available,
3. Touch SECTION again,
4. Select and type the subsection number,
5. Press the RETURN key on the primary keyboard.

At this time, please try the Section procedure to position the Army Operations file to the subsection on "Tank Division Combat Support". When you locate this line number, please enter it as the target line. Once again, if you have any difficulties, please ask the experimenter for help.

When using the Section procedure to browse sections in the file, it might be necessary for you to backup and choose a different section. This can be done using the DELETE key on the primary keyboard. Pressing the DELETE key will erase any entries, and if there is a semi-colon the DELETE key will backup and display the previous set of sections.

At this time, please use the Section procedure to select the subsections of the "Tank Division", and then use the DELETE key to to backup and find information on "Motorized Rifle Division Mission" When you are finished, enter this line number as the target line.

Additional Hints on the Section Procedure

If at anytime you want to cancel the Section procedure without changing the position of the file in the 7-line window, just touch another search procedure key.

Also, you might have noticed that some of the sections are highlighted. These highlighted section lines indicate that more specific data can be retrieved from additional files. Therefore, the Section procedure can be useful for finding the access points to this additional information.

Now, we would like you to use the Section procedure to find the target on the secondary display. Please refer to the search procedure reference sheet if you need a quick summary of the methods for the Section procedure. You will have one additional trial after this target to practice the Section procedure.

(Practice 1: Verify that an operational capability of the tank division is to defend in place in order to gain time for massing forces.
Practice 2: Verify that the motorized rifle division has a tank regiment subgroups.)

Now lets learn about the Search procedure.

SEARCH

The Search procedure can be used to scan the current computer file for a piece of text. The text can include any letter, digit, or special symbol that is on the keyboard. However, it is important to remember that a blank space is also recognized as a character. Therefore, "tank" and " tank" are different pieces of text. In addition, the difference between upper and lower case letters is not recognized by the Search procedure.

To use the Search procedure you must touch the SEARCH key on the touch keypad. The prompt "Search for:" will then be displayed on the input and message line. At this point you can type a piece of text that is up to 67 characters long through the primary keyboard. If you make a mistake when typing the text use the DELETE key to erase all or part of the text.

When you have finished typing the text, press the RETURN key to start the Search procedure. The Search procedure will attempt to find all occurrences of the text and will store up to 10 locations for you to browse.

To browse over the results of the Search procedure, press the BROWSE key on the keypad to the right of the primary keyboard. Each time it is pressed the BROWSE key will position the 7-line window at a new occurrence of the text.

A summary of the methods for using the Search procedure is:

1. Touch SEARCH on the touch keypad,
2. Type the text on the primary keyboard,
3. Press RETURN on the primary keyboard,
4. Press BROWSE on the keypad to the right of the primary keyboard.

At this time, please practice using the Search procedure to find the target on the secondary display. You will have two trials to practice the Search procedure. If you have any difficulties, please ask the experimenter for help.

(Practice 1: Locate the number of officers at the headquarters of a tank division.
Practice 2: Verify that a defense of the motorized rifle division is to defend a zone in the main defensive belt of the combined arms army.)

Now lets learn about the Search-And and Search-And-Not procedures.

SEARCH-AND/NOT

The Search-And, and the Search-And-Not procedures are extensions of the basic Search procedure so that multiple pieces of text can be searched for. The Search-And procedure allows you to look for up to 5 pieces of text within 7 lines of each other. The Search-And-Not procedure allows you to search for a piece of text without the occurrence of other text within 7 lines.

To use the Search-And procedure you can touch the SEARCH AND key on the touch keypad. The prompt "Search for:" will then be displayed on the input and message line. At this point you can type the first piece of text.

Subsequently, the other pieces of text that you wish to look for in combination with the first piece of text can be typed by touching the SEARCH AND key on the touch keypad and typing the text with the primary keyboard. You can repeat these steps until there are 5 pieces of text.

When you have finished entering the text, press the RETURN key to start the Search-And procedure. The Search-And procedure will store up to 10 locations for you to scan with the BROWSE key.

When using the Search-And procedure the DELETE key can be used for erasing AND prompts and text.

A summary of these procedures for using the Search-And procedure is:

1. Touch SEARCH AND on the touch keypad,
2. Type the first piece of text using the primary keyboard,
3. Touch SEARCH AND on the touch keypad,
4. Type the text using primary keyboard, (Please note that you can repeat steps 3 and 4 until 5 pieces of text are entered.)
5. Press RETURN to start the Search-And procedure,
6. Press BROWSE to view the locations that were found.

At this time, please try the Search-And procedure to find the line : "Tank Division Operational Capabilities". When you find it, enter the line number as the target number. If you have any difficulties please ask the experimenter for help.

To use the Search-And-Not procedure, first touch the SEARCH AND NOT key and type the text you would like to search for. Then, touch the SEARCH-AND-NOT key again and type the text that the Search procedure should exclude.

Once the text is entered, the RETURN, BROWSE, and DELETE keys on the keyboard will work exactly as they did with the Search-And procedure.

The Search-And-Not procedure can also be used with the Search-And procedure. The only restriction is that the text to be excluded must be entered last.

A summary of these procedures for using the Search-And-Not procedure is:

1. Touch SEARCH-AND-NOT on the touch keypad,
2. Type the first piece of text using the primary keyboard,
3. Enter any SEARCH-AND prompts and text,
4. Touch SEARCH-AND-NOT on the touch keypad,
5. Type the text to be excluded from search, (Please note that you can repeat steps 4 and 5 until 5 total pieces of text are entered.)
6. Press RETURN to start the Search-And-Not procedure,
7. Press BROWSE to view the locations that were found.

At this time, please try the Search-And-Not procedure to find information on "tank division without information on combat support". When you have line 39 at the top of the display, enter that line as the target number. If you have any difficulties, please ask the experimenter for help.

Now, we would like you to use the Search-And/Search-And-Not procedures to find the target on the secondary display. Please refer to the search procedure reference sheet if you need a quick summary of the methods for the Search-And/Search-And-Not procedures. You will have one additional trial to practice the Search-And/Search-Not procedures.

(Practice 1: Locate the number of officers in the rocket launcher battalions.
Practice 2: Locate the tank regiment subgroup that is not in motorized rifle division.)

Now lets learn about the Index procedure.

INDEX

The index procedure can be used to find information in the current computer file much like an index in a book is used to find special topics. To use the Index procedure, touch the key on the third line of the touch keypad. The computer will then generate the index in the work area of the primary display. This index contains an alphabetical list of topics and subtopics.

The index can be browsed by pressing the INDEX UP or INDEX DOWN keys on the keypad to the right of the primary keyboard. These keys move the index through the work area in much the same way that the PAGE UP and PAGE DOWN keys move the computer file through the 7-line window.

At this point, please touch the INDEX touch key, and use the INDEX UP and INDEX DOWN keys to position the index to the major topic of "Regiments".

If you see a topic that you want locations on, all you have to do is type this topic next to the "Index topic:" prompt and touch the INDEX key. If the topic you requested was a major topic then the Index procedure will ask you to enter a subtopic. Otherwise, the Index procedure will locate the subtopic and ask you to confirm your selection by touching the INDEX key.

After confirming an index topic the Index procedure will erase the index from the work area and display a list of line numbers for the topic chosen. You can then use the BROWSE key to look through the list of line numbers or you can enter a choice number of a location.

Finally, if you wish to return to the index from the location list, just press RETURN.

When entering the topic only the first few letters which identify the topic need to be entered. If there are multiple subtopics in an index, then the major topic must be selected first.

A summary of these procedures for selecting a topic in the index is:

1. Touch INDEX on the touch keypad,
2. Type a topic with the primary keyboard,
3. Touch the INDEX key again,
4. Confirm the topic by touching INDEX or select a subtopic,
5. BROWSE or select a choice of line locations,
6. Press RETURN to return to the index.

Now, we would like you to use the Index procedure to find the target on the secondary display. You will have one additional trial after this target to practice the Index procedure. If you have any problems please ask the experimenter for help.

(Practice 1: Locate the number of officers in a surface

to air missile regiment.
Practice 2: Verify that the motorized rifle division has a subgroup of independent tank battalions.)

Now lets learn about the Zoom-In and Out procedures.

ZOOM-IN AND ZOOM-OUT

The Zoom-In and Zoom-Out procedures are used for moving through the file hierarchy. The Zoom-In procedure accesses additional information for lines in the current file which are highlighted. The Zoom-Out procedure backs up to the previous file in the hierarchy.

To use the Zoom-In procedure touch the ZOOM-IN key on the touch keypad when a highlighted line appears in the 7-line window. To use the Zoom-Out procedure touch the ZOOM-OUT key at any time.

When using Zoom-In and Zoom-Out the top line of the primary display may be useful for orienting in the file hierarchy. In addition, the map of the file hierarchy may be useful during the training trials to learn the hierarchical file structure. However, do not rely to a great extent on this map, since it will not be available during the actual experiment.

At this time, please use the Zoom-In and Zoom-Out procedures to find the target shown on the secondary display. Please note that the Scroll Up and Down procedures are active to facilitate your exploration of the file hierarchy.

(Practice 1: Locate the total number of available T-72 tanks in the Bravo regiment.
Practice 2: Verify that the artillery regiment's mission is to provide fire support to the tank divisions making a main advance. HINT: look in the combat support files.)

Now lets learn about the File Select procedure.

FILE SELECT

The File Select procedure allows you to browse the file hierarchy before loading the actual computer files. The File Select procedure works very much like the Section procedure, except that the File Select procedure displays the structure of the file hierarchy.

To use the File Select procedure, touch the FILE SELECT key on the touch keypad. The prompt "File number:" will then be displayed on the input and message line. In addition, other files that can be accessed through the current file will be shown in the work area of the primary display.

A file can be selected at this point with the digit keys at the top of the primary keyboard. If the RETURN key is then pressed, the file you selected will be loaded into the 7-line window.

A summary of these procedures for browsing and choosing another file from the current file is:

1. Touch FILE SELECT on the touch keypad,
2. Select and type the file number with the digit keys on the primary keyboard,
3. Touch RETURN on the primary keyboard.

At this time, please try the File Select procedure to load the file on "Motorized Rifle Division Combat Support". When you get to this file, please enter line number 1 as the target number. If you have any difficulties, please ask the experimenter for help.

In addition to browsing and choosing files that are just below the current file in the hierarchy, the File Select procedure can also browse and select files that are more than one level below the current file.

To select and display these files touch the FILE SELECT key. Then check to see if there are any subfiles available by looking for a "*" by a file number. At this point, select a file that you would like to see subfiles on, and type the file number using the digit keys.

Next, to present these subfiles you must touch the FILE SELECT key again. Finally, one of these subfiles can be loaded into the 7-line window by typing the file number and pressing the RETURN key.

A summary of these procedures for browsing and selecting a file that is more than one level below the current file in the hierarchy is:

1. Touch FILE SELECT on the touch keypad,
2. Select and type the file number that has subfiles available,
3. Touch FILE SELECT again,

4. Select and type the subfile number,
5. Press the RETURN key on the primary keyboard.

At this time, please try the File Select procedure to load a file on the "PT-76 Tank Inventory and Availability". When you get to this file, enter line number 1 as the target number. If you have any difficulties, please ask the experimenter for help.

When using the File Select procedure to browse the file hierarchy, it might be necessary for you to backup and choose a different file. This can be done using the DELETE key on the primary keyboard. Pressing the DELETE key will erase any entries, and if there is a semi-colon the DELETE key will backup and display the previous set of files.

At this time, please use the File Select procedure to select subfiles for "Tank Equipment Statistics". Then use the DELETE key to backup and load the motorized rifle file "BMP-1 Inventory and Availability". When you get to this file, enter line number 1 as the target number.

Additional Hints on the File Select Procedure

If at anytime you want to cancel the File Select procedure without loading a new file in the 7-line window, just touch another search procedure key.

Also, you might have noticed that File Select procedures can only access the files that are below the current file in the hierarchy. If you want to view a larger portion of the file hierarchy, it will be necessary to backup using the Zoom-Out procedure.

Finally, when using File Select it may be useful to refer to the line above the 7-line window and the map of the file hierarchy. However, please use the map for training purposes only, since it will not be available during the actual experiment.

Now, we would like you to use the File Select procedure to find the target on the secondary display. Please refer to the search procedure reference sheet if you need a quick summary of the methods for the File Select procedure. The Scroll procedures are available for movement through individual files on this and the next practice trial.

(Practice 1: Verify that the Crater regiment of the motorized rifle division has 59 total BTR-50P armored personnel carriers (APCs).

Practice 2: Locate the size of the T-72 tank crew.)

That completes the first training session. Please see the experimenter.

Appendix G

SEARCH PROCEDURE REFERENCE SHEET

SEARCH PROCEDURE REFERENCE SHEET

SCROLL UP AND SCROLL DOWN

Touch SCROLL UP or SCROLL DOWN keys to move the current file line by line through the window.

PAGE UP AND PAGE DOWN

Touch PAGE UP or PAGE DOWN keys to move the current file 7 lines at a time through the window.

SECTION

To move the current file to a major section:

1. Touch SECTION key,
2. Type section number,
3. Press RETURN.

To move the current file to a subsection:

1. Touch SECTION key,
2. Type section number that has subsections,
3. Touch SECTION key,
4. Type subsection number,
5. Press RETURN.

Use the DELETE key to backup and to erase entries.

SEARCH

To Search for a piece of text in the current file:

1. Touch SEARCH key,
2. Type text,
3. Press RETURN,
4. Press BROWSE.

Use DELETE key to remove unneccessary text.

SEARCH-AND

To search for multiple pieces of text within 7 lines of each other:

1. Touch SEARCH AND key,
2. Type first piece of text,
3. Touch SEARCH AND key,
4. Type text,
   (Steps 3 and 4 can be repeated until 5 pieces of text exist.)
5. Press RETURN,
6. Press BROWSE.

Use DELETE to erase AND prompts and text.

SEARCH-AND-NOT

To search for multiple pieces of text within 7 lines of each other excluding some text:

1. Touch SEARCH AND NOT key,
2. Type first piece of text,
3. Enter any Search-And prompts and text,
4. Touch SEARCH AND NOT key,
5. Type text to be excluded,
   (Steps 4 and 5 can be repeated until 5 total pieces of text exist.)
6. Press RETURN,
7. Press BROWSE.

Use DELETE to erase AND, AND-NOT prompts and text.

INDEX

To select a topic in the index:

1. Touch INDEX,
2. Type a topic,
3. Touch INDEX,
4. Confirm the topic by touching INDEX or select a subtopic,
5. Press BROWSE or enter choice,
6. Press RETURN to return to index.

Use INDEX UP and INDEX DOWN on the keyboard to scan Index.
When entering topics only the first few letters which identify the topic need to entered.
If there are multiple subtopics in an index then the major topic must be selected first.

ZOOM-IN

Touch the ZOOM-IN key to load a file associated with a highlighted line in the window.

ZOOM-OUT

Touch ZOOM-OUT anytime to back up to the previous file in the hierarchy.

FILE SELECT

To browse and choose files from the current file:

1. Touch FILE SELECT key,
2. Type file number,
3. Press RETURN.

To browse and select files more than one level below current file:

1. Touch FILE SELECT key,
2. Type file number that has subfiles,
3. Touch FILE SELECT key,
4. Type subfile number,
5. Press RETURN.

Use the DELETE key to backup and to erase entries.
Use ZOOM-OUT to view a larger portion of file hierarchy.

Appendix H

SEARCH PROBLEMS USED IN THE EXPERIMENT

ITEM	CLUSTER	SEARCH PROBLEM
1	2	Locate the battle hours of the PT-76 tank with the Blue-5 maintenance battalion and a Waterjet maintenance code.
2	3	Locate the maintenance battalion of the armored personnel carrier with an ID code of 69024.
3	7	Locate the range of the armored personnel vehicle that does not have an armament.
4	10	Verify that an operational capability of the multiple rocket launcher battalion is to provide counter-bombardment.
5	9	Verify that there is a long range reconnaissance company that functions as a subgroup of the reconnaissance battalion.
6	1	Locate the BMP-1 vehicle that has a Searchlight maintenance code and the largest number of battle hours.
7	1	Verify that the BMP-1 armored personnel carrier number 6643A has 139 battle hours.
8	7	Locate the crew size of the armored personnel carrier that carries the largest number of infantry.
9	5	Locate the number of vehicles in the Razor regiment.
10	11	Locate the number of enlisted personnel in the maintenance battalion.
11	1	Locate the BTR-60 armored personnel carrier that has a Hydrojet maintenance code and is not on reserve.

ITEM	CLUSTER	SEARCH PROBLEM
12	9	Verify that the service battery is a subgroup of the multiple rocket launcher battalion.
13	10	Locate the first operational capability of the maintenance battalion.
14	1	Verify that the MT-LB with the ID code of 4DF6CD is stationed in the East.
15	12	Verify that the motorized rifled10 division attack as a second echelon division.
16	3	Locate the ID code of the armored personnel carrier that has a range of 400km, a maintenance code of Track, and a Yellow-2 maintenance battalion.
17	1	Locate the MT-LB vehicle that has a Engine maintenance code and is not stationed in the East, West, or South.
18	8	Locate the crew of the tank with a length of 6.715m, a width of 3.352m and a height of 2.4m.
19	7	Locate the height of the BMP-1 armored personnel carrier.
20	7	Verify that the main armament of the MT-LB tracked vehicle is turret mounted.
21	10	Verify that the anti-aircraft gun regiment operates as a part of march column.
22	9	Locate the only subgroup of the surface to air missile regiment.
23	1	Verify that the fifth BTR-60 armored personnel carrier in the Echo regiment is stationed in the South.
24	8	Verify that the T-62 vehicle can lay its own smoke column.
25	7	Locate the possible calibers of the machine guns that are mounted on the BTR-50P.

ITEM	CLUSTER	SEARCH PROBLEM
26	9	Locate the only subgroup of the anti-aircraft gun regiment.
27	2	Verify that the T-64 tank in the Bullet regiment with a Track maintenance code is serviced by the Yellow-4 maintenance battalion.
28	4	Verify that the heavy tank with ID code 343X is on reserve.
29	4	Locate the tank with ID code 370P.
30	1	Locate the BMP-1 armored personnel carrier in the Harrow regiment that is on reserve and has the fewest battle hours.
31	8	Verify that the T-72 tank has a water cooled diesel engine.
32	2	Locate the fourth tank in the T-72 Spearhead regiment.
33	9	Verify that anti-tank battalions are subgroups of the artillery regiment which supports the tank division.
34	3	Locate the vehicle with ID code 34037 that is on reserve and has 205 battle hours.
35	5	Verify that there are 14 available armored personnel carriers in the Lion regiment.
36	12	Verify that the motorized rifle division will sometimes operate as a front reserve.
37	8	Locate the main armament of the T-72 tank.
38	10	Verify that an operational capability of the reconnaissance battalion is to pinpoint key terrain.
39	7	Locate the secondary armament of the vehicle with the heavy machine gun.
40	8	Locate the speed of the tank with the smallest range.

ITEM	CLUSTER	SEARCH PROBLEM
41	7	Verify that the BTR-60 is believed to be inadequate for hard driving over rough ground.
42	7	Locate the amphibious speed of the armored personnel carrier that can climb a gradient of 30 degrees and is propelled by twin hydrojets.
43	2	Verify that the Arrow regiment has 18 T-72 tanks available.
44	8	Locate the firing rate of the T-10.
45	1	Locate the BTR-152 armored personnel carrier with a Wheel maintenance code in the Taurus regiment.
46	2	Locate the T-10 vehicle with the most battle hours.
47	1	Locate the BTR-152 armored personnel carrier that is stationed in the South with the ID code of C971.
48	1	Locate the MT-LB that has 110 battle hours and does not have the Blue-1 maintenance battalion.
49	7	Locate the road range of the vehicle with infra-red headlamps and viewers.
50	3	Locate the vehicle that can travel at 80km/hr and has an ID code of 9402B.
51	2	Locate the T-72 tank in the regiment number 890 that has a maintenance code.
52	3	Locate the armored personnel carrier with 1 battle hour that has a speed of 43 km/hr and a range of 250km.
53	12	Verify that there are motorized rifle regiments in the motorized rifle division.
54	6	Locate the tank regiment that has 10 35-ton tanks in total.
55	6	Locate the total number of available 37.5 ton battle tanks in regiment 103.

ITEM	CLUSTER	SEARCH PROBLEM
56	3	Locate the armored personnel carrier with dimensions 7.56m by 2.82m by 2.31m and 68 battle hours.
57	12	Verify that the tank division will conduct mobile counter-attack operations.
58	10	Verify that an operational capability of the reconnaissance battalion is to identify routes for advance and withdrawal for the tank division.
59	1	Locate the BTR-50P armored personnel carrier with 300 battle hours that is not on reserve.
60	4	Locate the T-62 tank with the Track maintenance code that has the largest number of battle hours.
61	4	Locate the battle tank with ID code 21XF.
62	7	Locate the horsepower of the BTR-152 armored personnel carrier.
63	1	Locate the possible calibers of the machine guns that are mounted on the BTR-50P.
64	4	Locate the amphibious tank with an ID code of 1942.
65	2	Locate the T-62 tank with the Track maintenance code that has the largest number of battle hours.
66	2	Locate the T-62 tank with a Yellow-6 maintenance battalion stationed in the West.
67	4	Locate the tank in regiment 567 with the most battle hours.
68	1	Locate the BTR-60 armored personnel carrier with the Rocket maintenance code that is in the Echo regiment.
69	9	Locate the messenger unit subgroup in the combat support forces of the motorized rifle division.

ITEM	CLUSTER	SEARCH PROBLEM
70	5	Verify that the Leopard regiment has 5 armored personnel carriers available.
71	6	Locate the total number of battle tanks in the Renegade regiment.
72	1	Verify that the fourth MT-LB armored personnel carrier in regiment 1852 is stationed in the Northwest.
73	3	Locate the vehicle with a crew of 13 that is in the Rover regiment and has an ID code of 4408E6.
74	5	Locate the total number of armored personnel carriers in regiment number 499.
75	2	Locate the T-62 tank with the Fuel maintenance code.
76	9	Locate the third subgroup of the signal battalion.
77	8	Verify that the T-64 tank does not have an automatic loader.
78	8	Locate the width of the light amphibious tank.
79	4	Verify that the tank with ID code 7282 has 19 battle hours.
80	2	Locate the T-62 tank in the Scorpion regiment with a Loader maintenance code.
81	1	Locate the BTR-60 armored personnel carrier with ID code 4AAE3 that is in the Forest regiment.
82	10	Verify that a mission of the artillery regiment supporting the motorized rifle division is to assist in the defense of critical areas.
83	3	Locate the maintenance battalion of the first armored personnel carrier in the Sahara regiment. Please note that this vehicle carries ammunition.

ITEM	CLUSTER	SEARCH PROBLEM
84	10	Verify that the engineer battalion can operate a sawmill.
85	1	Verify that a MT-LB in the Whiskey regiment has 4 battle hours.
86	2	Locate the T-10 tank with the Orange-5 maintenance battalion that has the fewest battle hours.
87	4	Locate the tank that has a loader as a crew member and an ID code of 2P12.
88	1	Locate the BTR-50P armored personnel carrier that has a Orange maintenance battalion, a Gun maintenance code, but is not stationed in the East or North.
89	8	Locate the method of ranging for the T-10 tank.
90	8	Locate the secondary armament of the tank that uses HVAP ammunition and does not use APFSDS ammunition.
91	2	Locate the PT-76 tank stationed in the South with a Green-3 maintenance crew and a Turret maintenance code.
92	2	Locate the T-64 tank with the Fuel maintenance code.
93	2	Locate the PT-76 tank on reserve with the most battle hours.
94	11	Locate the number of enlisted personnel in the medical battalion.
95	4	Verify that the heavy tank with the ID code 2721 has a Loader maintenance code.
96	11	Locate the number of enlisted personnel in an anti- aircraft gun regiment.

Appendix I

INSTRUCTIONS FOR SORTING SEARCH PROBLEMS

TARGET SORTING INSTRUCTIONS - PART I

On the index cards in front of you are the targets that you searched for during days 3-6. We are interested in how you would categorize these targets.

Your task is to sort these cards into groups that are meaningful to you. When you are finished please write a short description of the target features which characterize the group. This can be written on a blank index card.

In addition, please supply a few search plans for locating this information. That is, please list the sequence of search procedures you would use to locate each group of targets. This information can also be written on a blank index card. The search procedure reference sheet is available if you need to know the names and functions of the search procedures.

Use as many blank index cards as necessary for the descriptions and search plans. The experimenter will answer any questions you have about this procedure. When you are finished, please see the experimenter.

TARGET SORTING INSTRUCTIONS - PART II

Now we would like you to link the groups of targets with the larger index cards. That is, use the larger index cards to categorize the groups from Part I into larger and more general target classes. This can be done by placing the larger index card on top of the target groups that you believe are related. Once again, please write on the large index card a summary of each target class.

The experimenter will be available to answer any questions.

Appendix J

ANALYSIS OF VARIANCE SUMMARY TABLES

Experiment 1: Subject Groups (Novice, Experts) by Sessions (3 - 6)

Dependent Measure: Total Operations

Source	df	SS	F-ratio	p-value
Between Subjects				
GROUP (G)	1	265.00	6.04	0.0224
SUBJ/G	22	965.76		
Within Subjects				
SESSION (S)	3	157.02	11.07	0.0001
S*G	3	10.76	0.76	0.5246
S*SUBJ/G	66	312.09		
TOTAL	95	1710.63		

Dependent Measure: Different Operations

Source	df	SS	F-ratio	p-value
Between Subjects				
GROUP (G)	1	4.50	2.95	0.1002
SUBJ/G	22	33.64		
Within Subjects				
SESSION (S)	3	2.04	6.42	0.0008
S*G	3	0.12	0.39	0.7666
S*SUBJ/G	66	7.01		
TOTAL	95	47.31		

Dependent Measure: Total Time

Source	df	SS	F-ratio	p-value
Between Subjects				
GROUP (G)	1	16315.56	8.59	0.0077
SUBJ/G	22	41784.21		
Within Subjects				
SESSION (S)	3	14784.21	20.73	0.0001
S*G	3	711.57	1.01	0.3930
S*SUBJ/G	66	15426.31		
TOTAL	95	88771.50		

Dependent Measure: Total Movement

Source	df	SS	F-ratio	p-value
Between Subjects				
GROUP (G)	1	33488.01	2.70	0.1147
SUBJ/G	22	273024.03		
Within Subjects				
SESSION (S)	3	20784.81	4.91	0.0040
S*G	3	772.97	0.18	0.9057
S*SUBJ/G	66	93099.97		
TOTAL	95	421169.80		

Experiment 1: Subject Groups (Slow Novices n = 6, Fast Novices n = 6, Experts, n = 12) by Sessions (3 - 6)

Dependent Measure: Total Operations

Source	df	Type III SS	F-ratio	p-value
Between Subjects				
GROUP (G)	2	708.83	14.26	0.0001
SUBJ/G	21	521.93		
Within Subjects				
SESSION (S)	3	163.19	11.24	0.0001
S*G	6	17.99	0.62	0.7137
S*SUBJ/G	63	304.85		
TOTAL	95	1710.63		

Dependent Measure: Different Operations

Source	df	Type III SS	F-ratio	p-value
Between Subjects				
GROUP (G)	2	15.89	7.50	0.0035
SUBJ/G	21	22.25		
Within Subjects				
SESSION (S)	3	2.02	6.14	0.0011
S*G	6	0.22	0.34	0.9149
S*SUBJ/G	63	6.91		
TOTAL	95	47.31		

Dependent Measure: Total Time

Source	df	Type III SS	F-ratio	p-value
Between Subjects				
GROUP (G)	2	42194.62	27.86	0.0001
SUBJ/G	21	15905.16		
Within Subjects				
SESSION (S)	3	15123.36	21.17	0.0001
S*G	6	1133.26	0.79	0.5788
S*SUBJ/G	63	15004.63		
TOTAL	95	88771.50		

Dependent Measure: Total Movement

Source	df	Type III SS	F-ratio	p-value
Between Subjects				
GROUP (G)	2	138095.25	8.61	0.0019
SUBJ/G	21	168416.80		
Within Subjects				
SESSION (S)	3	18633.02	4.32	0.0079
S*G	6	3374.75	0.39	0.8818
S*SUBJ/G	63	90498.19		
TOTAL	95	421169.80		

Experiment 1: Search Strategy Analyses for Slow Novices (n = 6), Fast Novices (n = 6), and Experts (n = 12)

Dependent Measure: Scroll Up Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	2	0.1802	4.57	0.0225
SUBJ/G	21	0.4142		
TOTAL	23	0.5944		

Dependent Measure: Scroll Down Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	2	0.3925	5.85	0.0096
SUBJ/G	21	0.7043		
TOTAL	23	1.0968		

Dependent Measure: Page Up Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	2	0.0040	0.14	0.8678
SUBJ/G	21	0.2963		
TOTAL	23	0.3003		

Dependent Measure: Page Down Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	2	0.0580	0.48	0.6270
SUBJ/G	21	1.2751		
TOTAL	23	1.3331		

Dependent Measure: Section Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	2	0.0685	0.91	0.4162
SUBJ/G	21	0.7864		
TOTAL	23	0.8549		

Dependent Measure: Zoom In Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	2	0.2177	1.26	0.3046
SUBJ/G	21	1.8166		
TOTAL	23	2.0343		

Dependent Measure: Zoom Out Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	2	0.1064	11.00	0.0005
SUBJ/G	21	0.1015		
TOTAL	23	0.2079		

Dependent Measure: File Select Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	2	0.0479	0.38	0.6891
SUBJ/G	21	1.3264		
TOTAL	23	1.3743		

Dependent Measure: Search Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	2	0.0289	0.33	0.7223
SUBJ/G	21	0.9201		
TOTAL	23	0.9491		

Dependent Measure: Search-And Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	2	0.0060	0.25	0.7811
SUBJ/G	21	0.2524		
TOTAL	23	0.2584		

Dependent Measure: Search-And-Not Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	2	0.0002	2.49	0.1073
SUBJ/G	21	0.0007		
TOTAL	23	0.0009		

Dependent Measure: Index Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	2	0.0511	1.68	0.2111
SUBJ/G	21	0.3203		
TOTAL	23	0.3715		

Experiment 1: Subject Groups (Novice, Experts) by Search Clusters (1 - 12)

Dependent Measure: Total Operations

Source	df	SS	F-ratio	p-value
Between Subjects				
GROUP (G)	1	1028.24	4.75	0.0403
SUBJ/G	22	4762.85		
Within Subjects				
CLUSTER (C)	11	4849.97	11.72	0.0001
C*G	11	351.83	0.85	0.5910
C*SUBJ/G	242	9105.25		
TOTAL	287	20098.15		

Dependent Measure: Different Operations

Source	df	SS	F-ratio	p-value
Between Subjects				
GROUP (G)	1	13.52	2.35	0.1396
SUBJ/G	22	126.58		
Within Subjects				
CLUSTER (C)	11	136.46	16.31	0.0001
C*G	11	6.08	0.73	0.7138
C*SUBJ/G	242	184.05		
TOTAL	287	466.68		

Dependent Measure: Total Time

Source	df	SS	F-ratio	p-value
Between Subjects				
GROUP (G)	1	60101.40	5.71	0.0258
SUBJ/G	22	231456.09		
Within Subjects				
CLUSTER (C)	11	156832.10	5.65	0.0001
C*G	11	28943.03	1.04	0.4089
C*SUBJ/G	242	610331.88		
TOTAL	287	1087664.49		

Dependent Measure: Total Movement

Source	df	SS	F-ratio	p-value
Between Subjects				
GROUP (G)	1	106960.42	2.04	0.1668
SUBJ/G	22	1150897.79		
Within Subjects				
CLUSTER (C)	11	1396200.64	11.06	0.0001
C*G	11	81985.85	0.65	0.7861
C*SUBJ/G	242	2777475.94		
TOTAL	287	5513520.49		

Experiment 1: Subject Groups (Novice, Experts) by Search Clusters (1 - 12) by Search Procedures

Dependent Measure: Average Polls

Source	df	SS	F-ratio	p-value
Between Subjects				
GROUP (G)	1	1.13	2.35	0.1396
SUBJ/G	22	10.55		
Within Subjects				
CLUSTER (C)	11	11.37	16.31	0.0001
C*G	11	0.51	0.73	0.7138
C*SUBJ/G	242	15.34		
SEARCH PROCEDURE (S)	11	145.10	30.25	0.0001
S*G	11	3.49	0.73	0.7135
S*SUBJ/G	242	105.53		
C*S	121	54.41	12.87	0.0001
C*S*G	121	6.70	1.58	0.0001
C*S*SUBJ/G	2662	93.02		
TOTAL	3455	447.13		

Experiment 2: Novice Subject Comparability Analysis During the Last 12 Training Trials (Control, Frequency, Sequence, and Plan Novices)

Dependent Measure: Total Operations

Source	df	SS	F-ratio	p-value
GROUP (G)	3	13.56	0.22	0.8850
SUBJ/G	44	921.71		
TOTAL	47	935.27		

Dependent Measure: Different Operations

Source	df	SS	F-ratio	p-value
GROUP (G)	3	1.59	0.78	0.5101
SUBJ/G	44	29.71		
TOTAL	47	31.30		

Dependent Measure: Total Time

Source	df	SS	F-ratio	p-value
GROUP (G)	3	1335.15	0.29	0.8344
SUBJ/G	44	68181.42		
TOTAL	47	69516.57		

Dependent Measure: Total Movement

Source	df	SS	F-ratio	p-value
GROUP (G)	3	454.33	0.04	0.9883
SUBJ/G	44	157799.32		
TOTAL	47	158253.65		

Experiment 2: Models (Control Novices, Frequency Novices Sequence Novices, Plan Novices, Experts) by Sessions (3 - 5)

Dependent Measure: Total Operations

Source	df	SS	F-ratio	p-value
Between Subjects				
MODEL (M)	4	281.40	2.76	0.0367
SUBJ/M	55	1403.46		
Within Subjects				
SESSION (S)	2	396.38	35.38	0.0001
S*M	8	47.78	1.07	0.3922
S*SUBJ/M	110	616.28		
TOTAL	179	2745.30		

Dependent Measure: Different Operations

Source	df	SS	F-ratio	p-value
Between Subjects				
MODEL (M)	4	4.89	1.27	0.2919
SUBJ/M	55	52.84		
Within Subjects				
SESSION (S)	2	6.07	23.12	0.0001
S*M	8	0.59	0.56	0.8088
S*SUBJ/M	110	14.43		
TOTAL	179	78.82		

Dependent Measure: Total Time

Source	df	SS	F-ratio	p-value
Between Subjects				
MODEL (M)	4	26288.13	4.05	0.0032
SUBJ/M	55	80357.81		
Within Subjects				
SESSION (S)	2	48039.23	72.79	0.0001
S*M	8	5319.48	2.02	0.0510
S*SUBJ/M	110	36296.67		
TOTAL	179	196301.31		

Dependent Measure: Total Movement

Source	df	SS	F-ratio	p-value
Between Subjects				
MODEL (M)	4	38906.94	1.31	0.2762
SUBJ/M	55	407080.67		
Within Subjects				
SESSION (S)	2	67064.27	23.96	0.0001
S*M	8	7920.88	0.71	0.6844
S*SUBJ/M	110	153945.84		
TOTAL	179	674918.59		

Experiment 2: Models (Slow Novices n = 6, Fast Novices n = 6, Frequency Novices n = 12, Sequence Novices n = 12, Plan Novices n = 12 , Experts n = 12) by Sessions (3 - 5)

Dependent Measure: Total Operations

Source	df	Type III SS	F-ratio	p-value
Between Subjects				
MODEL (M)	5	597.45	5.93	0.0002
SUBJ/M	54	1087.41		
Within Subjects				
SESSION (S)	2	367.57	32.54	0.0001
S*M	10	54.14	0.96	0.4836
S*SUBJ/M	108	609.91		
TOTAL	179	2745.30		

Dependent Measure: Different Operations

Source	df	Type III SS	F-ratio	p-value
Between Subjects				
MODEL (M)	5	13.48	3.29	0.0116
SUBJ/M	54	44.25		
Within Subjects				
SESSION (S)	2	5.11	19.25	0.0001
S*M	10	0.69	0.52	0.8752
S*SUBJ/M	108	14.34		
TOTAL	179	78.82		

Dependent Measure: Total Time

Source	df	Type III SS	F-ratio	p-value
Between Subjects				
MODEL (M)	5	45834.15	8.14	0.0001
SUBJ/M	54	60811.79		
Within Subjects				
SESSION (S)	2	41753.47	62.85	0.0001
S*M	10	5740.21	1.73	0.0834
S*SUBJ/M	108	35875.94		
TOTAL	179	196301.31		

Dependent Measure: Total Movement

Source	df	Type III SS	F-ratio	p-value
Between Subjects				
MODEL (M)	5	111934.50	3.62	0.0069
SUBJ/M	54	334053.11		
Within Subjects				
SESSION (S)	2	56765.91	20.20	0.0001
S*M	10	10133.55	0.72	0.7029
S*SUBJ/M	108	151733.17		
TOTAL	179	674918.59		

Experiment 2: Dialogue (User, Computer, Mixed) by Presentation Order (MUC, MCU, CMU, CUM, UCM UMC) by Model (Control Novices, Frequency Novices, Sequence Novices, Plan Novices, Experts)

Dependent Measure: Total Operations

Source	df	SS	F-ratio	p-value
Between Subjects				
MODEL (M)	2	63.82	1.36	0.2812
PRESENTATION ORDER (O)	5	11.59	0.10	0.9911
M*O	10	282.73	1.21	0.3491
SUBJ/M*O	18	421.60		
Within Subjects				
DIALOGUE INITIATIVE (D)	2	50.50	7.26	0.0022
D*M	4	11.38	0.82	0.5223
D*O	10	431.00	12.39	0.0001
D*M*O	20	100.81	1.45	0.1625
D*SUBJ/M*O	36	125.19		
TOTAL	107	1498.61		

Dependent Measure: Different Operations

Source	df	SS	F-ratio	p-value
Between Subjects				
MODEL (M)	2	1.03	0.69	0.5126
PRESENTATION ORDER (O)	5	5.66	1.52	0.2322
M*O	10	7.11	0.96	0.5102
SUBJ/M*O	18	13.38		
Within Subjects				
DIALOGUE INITIATIVE (D)	2	2.04	10.28	0.0003
D*M	4	0.04	0.09	0.9852
D*O	10	7.27	7.31	0.0001
D*M*O	20	2.11	1.06	0.4244
D*SUBJ/M*O	36	3.57		
TOTAL	107	42.24		

Dependent Measure: Total Time

Source	df	SS	F-ratio	p-value
Between Subjects				
MODEL (M)	2	2098.06	1.08	0.3591
PRESENTATION ORDER (O)	5	11721.52	2.42	0.0757
M*O	10	19019.24	1.97	0.1017
SUBJ/M*O	18	17409.60		
Within Subjects				
DIALOGUE INITIATIVE (D)	2	3190.48	5.03	0.0119
D*M	4	707.35	0.56	0.6949
D*O	10	47856.27	15.09	0.0001
D*M*O	20	4635.95	0.73	0.7696
D*SUBJ/M*O	36	11420.11		
TOTAL	107	118058.57		

Dependent Measure: Total Movement

Source	df	SS	F-ratio	p-value
Between Subjects				
MODEL (M)	2	16617.84	1.10	0.3538
PRESENTATION ORDER (O)	5	10139.55	0.27	0.9243
M*O	10	76432.92	1.01	0.4695
SUBJ/M*O	18	135808.12		
Within Subjects				
DIALOGUE INITIATIVE (D)	2	6696.48	4.48	0.0183
D*M	4	3125.33	1.05	0.3922
D*O	10	77655.75	10.40	0.0001
D*M*O	20	21089.62	1.41	0.1798
D*SUBJ/M*O	36	26890.51		
TOTAL	107	374456.13		

Experiment 2: Dialogue Orders (MUC, MCU, CMU, CUM, UCM, UMC, Slow Novices, Fast Novices, Experts) by Sessions (3 - 5), Experts n = 12, Other Groups n = 6

Dependent Measure: Total Operations

Source	df	Type III SS	F-ratio	p-value
Between Subjects				
DIALOGUE ORDER (O)	8	545.22	3.05	0.0070
SUBJ/O	51	1139.65		
Within Subjects				
SESSION (S)	2	420.17	45.77	0.0001
S*O	16	195.85	2.67	0.0015
S*SUBJ/O	102	468.20		
TOTAL	179	2745.30		

Dependent Measure: Different Operations

Source	df	Type III SS	F-ratio	p-value
Between Subjects				
DIALOGUE ORDER (O)	8	18.11	2.91	0.0093
SUBJ/O	51	39.62		
Within Subjects				
SESSION (S)	2	6.20	30.29	0.0001
S*O	16	4.59	2.80	0.0009
S*SUBJ/O	102	10.44		
TOTAL	107	78.82		

Dependent Measure: Total Time

Source	df	Type III SS	F-ratio	p-value
Between Subjects				
DIALOGUE ORDER (O)	8	55457.61	6.91	0.0001
SUBJ/O	51	51188.33		
Within Subjects				
SESSION (S)	2	50423.05	89.96	0.0001
S*O	16	13031.29	2.91	0.0006
S*SUBJ/O	102	28584.86		
TOTAL	107	196301.32		

Dependent Measure: Total Movement

Source	df	Type III SS	F-ratio	p-value
Between Subjects				
DIALOGUE ORDER (O)	8	105456.20	1.97	0.0688
SUBJ/O	51	340531.41		
Within Subjects				
SESSION (S)	2	69697.73	27.27	0.0001
S*O	16	31700.04	1.55	0.0961
S*SUBJ/O	102	130166.68		
TOTAL	107	674918.59		

Experiment 2: User interaction with the Online Aids - Models (Frequency, Sequence, Plan) by Sessions (3 - 5)

Dependent Measure: Advice/Trial

Source	df	SS	F-ratio	p-value
Between Subjects				
MODEL (M)	2	6.40	12.45	0.0001
SUBJ/M	33	8.47		
Within Subjects				
SESSION (S)	2	2.02	4.43	0.0156
S*M	4	3.05	3.34	0.0150
S*SUBJ/M	66	15.06		
TOTAL	107	35.00		

Dependent Measure: Proportion of Advised Trials

Source	df	SS	F-ratio	p-value
Between Subjects				
MODEL (M)	2	0.10	0.69	0.5083
SUBJ/M	33	2.27		
Within Subjects				
SESSION (S)	2	0.30	1.95	0.1502
S*M	4	0.22	0.73	0.5754
S*SUBJ/M	66	5.08		
TOTAL	107	7.97		

Experiment 2: User Interaction with the Online Aid - Dialogue Initiative (User, Computer, Mixed) by Presentation Order (MUC, MCU, CMU, CUM, UCM UMC) by Model (Frequency, Sequence, Plan)

Dependent Measure: Advice/Trial

Source	df	SS	F-ratio	p-value
Between Subjects				
MODEL (M)	2	6.40	10.48	0.0010
PRESENTATION ORDER (O)	5	1.00	0.65	0.6631
M*O	10	1.99	0.65	0.7533
SUBJ/M*O	18	5.49		
Within Subjects				
DIALOGUE INITIATIVE (D)	2	4.82	15.08	0.0001
D*M	4	0.75	1.17	0.3389
D*O	10	3.18	1.99	0.0646
D*M*O	20	5.63	1.76	0.0686
D*SUBJ/M*O	36	5.76		
TOTAL	107	35.00		

Dependent Measure: Proportion of Advised Trials

Source	df	SS	F-ratio	p-value
GROUP (G)	2	0.10	0.55	0.5878
PRESENTATION ORDER (O)	5	0.34	0.79	0.5704
G*O	10	0.36	0.42	0.9184
SUBJ/G*O	18	1.56		
DIALOGUE INITIATIVE (D)	2	3.30	69.46	0.0001
D*G	4	0.27	2.81	0.0398
D*O	10	0.57	2.41	0.0262
D*G*O	20	0.62	1.31	0.2355
D*SUBJ/G*O	36	0.85		
TOTAL	107	7.97		

Experiment 2: Transfer Performance for Slow Novices (n = 6), Fast Novices (n = 6), Frequency Novices (n = 12), Sequence Novices (n = 12), Plan Novices (n = 12), and Experts (n = 12)

Dependent Measure: Total Operations

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	5	193.23	4.84	0.0011
SUBJ/G	54	431.57		
TOTAL	59	624.79		

Dependent Measure: Different Operations

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	5	3.74	3.05	0.0169
SUBJ/G	54	13.22		
TOTAL	59	16.96		

Dependent Measure: Total Time

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	5	9209.88	7.41	0.0001
SUBJ/G	54	13938.69		
TOTAL	59	23148.57		

Dependent Measure: Total Movement

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	5	46202.41	4.11	0.0032
SUBJ/G	54	121491.69		
TOTAL	59	167694.10		

Experiment 2: Search Strategy Analyses for Slow Novices (n = 6), Fast Novices (n = 6), Frequency Novices (n = 12), Sequence Novices (n = 12), Plan Novices (n = 12), Experts (n = 12)

Dependent Measure: Scroll Up Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	5	0.1934	2.41	0.0480
SUBJ/G	54	0.8679		
TOTAL	59	1.0613		

Dependent Measure: Scroll Down Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	5	0.4936	2.44	0.0455
SUBJ/G	54	2.1856		
TOTAL	59	2.6793		

Dependent Measure: Page Up Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	5	0.0178	0.23	0.9452
SUBJ/G	54	0.8261		
TOTAL	59	0.8439		

Dependent Measure: Page Down Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	5	0.1501	0.57	0.7237
SUBJ/G	54	2.8374		
TOTAL	59	2.9876		

Dependent Measure: Section Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	5	0.2447	2.13	0.0746
SUBJ/G	54	1.2386		
TOTAL	59	1.4833		

Dependent Measure: Zoom In Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	5	0.2105	0.88	0.5002
SUBJ/G	54	3.3081		
TOTAL	59	3.3577		

Dependent Measure: Zoom Out Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	5	0.1234	5.10	0.0007
SUBJ/G	54	0.2616		
TOTAL	59	0.3851		

Dependent Measure: File Select Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	5	0.2262	1.30	0.2757
SUBJ/G	54	1.8745		
TOTAL	59	2.1008		

Dependent Measure: Search Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	5	0.0572	0.35	0.8833
SUBJ/G	54	1.7904		
TOTAL	59	1.8477		

Dependent Measure: Search-And Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	5	0.0273	0.65	0.6683
SUBJ/G	54	0.4574		
TOTAL	59	0.4847		

Dependent Measure: Search-And-Not Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	5	0.0003	1.02	0.4172
SUBJ/G	54	0.0031		
TOTAL	59	0.0034		

Dependent Measure: Index Proportion

Source	df	Type III SS	F-ratio	p-value
GROUP (G)	5	0.0751	1.52	0.1993
SUBJ/G	54	0.5351		
TOTAL	59	0.6101		

Experiment 2: Overall Satisfaction with the Online Aids - Models (Frequency, Sequence, Plan) by Dialogue Initiatives (User, Computer, Mixed)

Dependent Measure: Unsatisfactory-Satisfactory

Source	df	Type III SS	F-ratio	p-value
Between Subjects				
MODEL (M)	2	10.85	1.87	0.1703
SUBJ/M	33	95.83		
Within Subjects				
DIALOGUE INITIATIVE (D)	2	0.57	0.20	0.8169
D*M	4	0.95	0.17	0.9526
D*SUBJ/M	63	88.17		
TOTAL	104	195.33		

Experiment 2: Reduced Analysis of Coleman's (1985) Individual Bipolar Scales - Scales (2 - 9) by Model (Frequency, Sequence, Plan) by Dialogue Initiatives (User, Computer, Mixed)

Dependent Measure: Mean Rating for a Dialogue Presentation Order

Source	df	SS	F-ratio	p-value
Between Subjects				
MODEL (M)	2	48.91	1.93	0.1797
ORDER/M	15	190.16		
Within Subjects				
DIALOGUE INITIATIVE (D)	2	3.91	0.80	0.4581
D*M	4	15.83	1.62	0.1945
D*ORDER/M	30	73.20		
SCALE (S)	7	51.65	7.85	0.0001
S*M	14	24.62	1.87	0.0380
S*ORDER/M	105	98.74		
D*S	14	5.14	0.81	0.6548
D*S*M	28	8.81	0.70	0.8728
D*S*ORDER/M	210	94.94		
TOTAL	104	615.92		

Experiment 2: Individual Bipolar Scales and Online Aids - Models (Frequency, Sequence, Plan) by Dialogue Initiatives (User, Computer, Mixed)

Dependent Measure: Unnatural-Natural

Source	df	Type III SS	F-ratio	p-value
MODEL (M)	2	11.54	1.91	0.1641
SUBJ/M	33	99.67		
TOTAL	104	195.33		

Dependent Measure: Undependable-Dependable

Source	df	Type III SS	F-ratio	p-value
MODEL (M)	2	32.25	4.79	0.0149
SUBJ/M	33	111.12		
TOTAL	104	204.19		

Dependent Measure: Complex-Simple

Source	df	Type III SS	F-ratio	p-value
MODEL (M)	2	9.33	1.84	0.1755
SUBJ/M	33	83.84		
TOTAL	104	187.43		

Dependent Measure: Slow-Fast

Source	df	Type III SS	F-ratio	p-value
MODEL (M)	2	21.61	3.17	0.0552
SUBJ/M	33	112.62		
TOTAL	104	212.23		

Dependent Measure: Incomplete-Complete

Source	df	Type III SS	F-ratio	p-value
MODEL (M)	2	7.95	0.86	0.4329
SUBJ/M	33	152.67		
TOTAL	104	236.53		

Dependent Measure: Disgusting-Pleasing

Source	df	Type III SS	F-ratio	p-value
MODEL (M)	2	25.90	3.37	0.0465
SUBJ/M	33	126.74		
TOTAL	104	237.56		

Dependent Measure: Uncooperative-Cooperative

Source	df	Type III SS	F-ratio	p-value
MODEL (M)	2	21.55	2.53	0.0948
SUBJ/M	33	140.36		
TOTAL	104	247.20		

Dependent Measure: Useless-Useful

Source	df	Type III SS	F-ratio	p-value
MODEL (M)	2	18.39	2.50	0.0973
SUBJ/M	33	121.27		
TOTAL	104	221.43		

Experiment 2: Reduced Analysis of Last 3 Individual Bipolar Scales Used to Assess the Advice-Giving Characteristics of the Online Aids - Scale (10 - 12) by Model (Frequency, Sequence, Plan) by Dialogue Initiatives (User, Computer, Mixed)

Dependent Measure: Mean Rating from a Dialogue Presentation Order

Source	df	SS	F-ratio	p-value
Between Subjects				
MODEL (M)	2	16.44	1.49	0.2574
ORDER/M	15	82.90		
Within Subjects				
DIALOGUE INITIATIVE (D)	2	1.40	0.42	0.6623
D*G	4	2.13	0.32	0.8635
D*ORDER/M	30	50.19		
SCALE (S)	7	1.84	0.47	0.6283
S*M	14	1.85	0.24	0.9150
S*ORDER/M	105	58.53		
D*S	14	1.26	0.77	0.5467
D*S*M	28	6.27	1.93	0.0725
D*S*ORDER/M	210	24.42		
TOTAL	104	247.24		

Appendix K

FREQUENCY PROFILES OF EXPERT SUBJECTS

	Search Procedures											
Search Cluster	1	2	3	4	5	6	7	8	9	10	11	12
1	21	72	13	28	5	177	44	9	1	21	7	188
2	24	49	21	24	3	118	41	0	3	68	3	133
3	40	17	31	19	5	86	37	0	12	48	43	89
4	14	29	12	18	12	107	6	0	16	56	51	75
5	9	14	4	12	5	26	0	0	4	11	36	33
6	25	26	12	21	5	43	3	0	10	28	30	30
7	28	55	19	29	17	70	27	0	18	20	39	110
8	37	54	12	21	15	61	24	3	17	61	21	63
9	28	30	12	10	18	39	16	0	47	23	29	63
10	30	40	8	16	21	36	16	0	49	26	28	63
11	7	9	7	7	10	18	1	0	22	3	16	14
12	18	25	5	10	14	25	5	0	12	4	20	17

Search Procedures:

1. SCROLL UP
2. SCROLL DOWN
3. PAGE UP
4. PAGE DOWN
5. SECTION
6. SEARCH
7. SEARCH-AND
8. SEARCH-AND-NOT
9. INDEX
10. ZOOM IN
11. ZOOM OUT
12. FILE SELECT

Cluster descriptions are given on the next page.

Cluster 1: Specific APC Inventory.
Cluster 2: Specific Tank Inventory.
Cluster 3: Unspecified APC Inventory (Embedded).
Cluster 4: Unspecified Tank Inventory (Embedded).
Cluster 5: Unspecified APC Inventory (Nonembedded).
Cluster 6: Unspecified Tank Inventory (Nonembedded).
Cluster 7: Equipment for APC.
Cluster 8: Equipment for Tank.
Cluster 9: Combat Support Information (Subgroups).
Cluster 10: Combat Support Information (Mission and Operations).
Cluster 11: Army Operations (Numerical).
Cluster 12: Army Operations (Verbal).

Appendix L

TRANSITION MATRICES AND INITIAL PROFILES OF EXPERT SUBJECTS

Transition Matrix and Initial Profile for Cluster 1
Specific APC Inventory

	To												Initial Search Profile
From	1	2	3	4	5	6	7	8	9	10	11	12	
1	15	17	1	1	0	2	0	0	0	1	1	0	0
2	13	42	2	1	1	4	0	0	0	2	2	0	2
3	1	2	3	7	2	0	1	0	0	2	2	0	0
4	1	4	7	10	1	8	2	0	0	10	0	2	11
5	0	0	0	2	2	2	0	0	0	1	2	1	1
6	8	50	5	9	0	24	4	0	0	13	3	0	4
7	2	6	1	0	0	13	44	37	0	0	0	0	0
8	0	0	0	0	0	0	2	16	0	0	0	0	0
9	0	0	0	0	1	0	0	0	0	0	0	0	0
10	0	0	0	7	2	14	0	0	0	4	4	0	1
11	1	1	0	1	2	1	0	0	0	3	0	4	0
12	0	2	0	6	1	114	64	0	1	2	0	5	185

Search Procedures:

1. SCROLL UP
2. SCROLL DOWN
3. PAGE UP
4. PAGE DOWN
5. SECTION
6. SEARCH
7. SEARCH-AND
8. SEARCH-AND-NOT
9. INDEX
10. ZOOM IN
11. ZOOM OUT
12. FILE SELECT

Transition Matrix and Initial Profile for Cluster 2
Specific Tank Inventory

From	To 1	2	3	4	5	6	7	8	9	10	11	12	Initial Search Profile
1	10	9	0	0	0	6	0	0	0	1	0	0	0
2	12	28	2	3	0	3	1	o	0	0	0	0	0
3	2	1	5	5	0	0	0	0	0	2	0	0	0
4	1	2	13	10	0	4	1	0	0	1	0	0	1
5	0	0	0	0	0	0	0	0	0	3	0	0	0
6	8	27	6	8	0	21	2	0	0	17	1	0	0
7	1	3	1	1	0	3	41	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	1	0	1	1	1
10	0	5	0	6	3	29	2	0	0	13	1	33	67
11	0	0	0	0	0	1	0	0	0	0	0	2	0
12	0	10	0	7	0	78	37	0	2	0	0	1	99

Search Procedures:

1. SCROLL UP
2. SCROLL DOWN
3. PAGE UP
4. PAGE DOWN
5. SECTION
6. SEARCH
7. SEARCH-AND
8. SEARCH-AND-NOT
9. INDEX
10. ZOOM IN
11. ZOOM OUT
12. FILE SELECT

Transition Matrix and Initial Profile for Cluster 3
Unspecified APC Inventory: Embedded

	To												Initial Search Profile
From	1	2	3	4	5	6	7	8	9	10	11	12	
1	31	3	0	1	0	1	0	0	0	24	2	14	0
2	7	12	0	0	0	6	1	0	1	0	1	0	1
3	2	1	7	7	0	2	0	0	0	12	4	8	0
4	1	0	12	8	0	3	1	0	1	7	8	1	2
5	0	0	0	0	2	0	0	0	3	2	0	0	0
6	19	5	12	6	0	9	0	0	0	4	35	0	2
7	16	3	8	0	0	2	37	0	0	1	4	0	1
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	5	0	1	0	0	0	1	0	2	7	1
10	0	3	0	6	0	35	10	0	1	7	2	1	16
11	0	2	1	7	1	5	3	0	2	2	15	36	0
12	0	3	0	4	3	62	30	0	8	8	2	6	73

Search Procedures:

1. SCROLL UP
2. SCROLL DOWN
3. PAGE UP
4. PAGE DOWN
5. SECTION
6. SEARCH
7. SEARCH-AND
8. SEARCH-AND-NOT
9. INDEX
10. ZOOM IN
11. ZOOM OUT
12. FILE SELECT

Transition Matrix and Initial Profile for Cluster 4
Unspecified Tank Inventory: Embedded

From	To 1	2	3	4	5	6	7	8	9	10	11	12	Initial Search Profile
1	10	7	2	1	0	0	1	0	0	5	2	2	0
2	7	17	0	1	0	5	1	0	0	0	2	2	0
3	0	0	1	2	0	1	0	0	2	6	1	1	0
4	0	1	6	9	0	7	1	0	1	4	0	1	0
5	0	0	0	0	2	2	0	0	1	4	0	6	1
6	7	22	3	5	0	4	0	0	0	14	45	10	1
7	2	0	1	0	0	1	6	1	0	0	1	0	0
8	1	1	0	0	0	0	0	0	0	0	0	0	0
9	1	0	0	1	3	0	0	0	1	5	0	9	4
10	0	4	0	5	4	44	4	0	4	24	3	4	48
11	1	1	2	7	1	3	1	0	2	7	2	35	0
12	0	4	0	2	5	72	1	0	5	1	3	7	54

Search Procedures:

1. SCROLL UP
2. SCROLL DOWN
3. PAGE UP
4. PAGE DOWN
5. SECTION
6. SEARCH
7. SEARCH-AND
8. SEARCH-AND-NOT
9. INDEX
10. ZOOM IN
11. ZOOM OUT
12. FILE SELECT

Transition Matrix and Initial Profile for Cluster 5
Unspecified APC Inventory: Nonembedded

	To												Initial Search Profile
From	1	2	3	4	5	6	7	8	9	10	11	12	
1	7	5	1	0	1	1	0	0	1	0	1	1	0
2	6	12	0	0	1	2	0	0	1	0	11	0	0
3	0	0	0	1	0	0	0	0	0	2	1	0	0
4	3	2	2	2	0	0	0	0	1	3	9	0	2
5	1	1	0	1	2	0	0	0	0	1	2	2	0
6	5	1	0	0	0	3	2	0	1	2	20	1	2
7	0	1	1	0	0	0	3	1	0	0	2	1	0
8	0	1	0	0	0	0	1	0	0	0	1	0	0
9	0	1	0	1	1	0	0	0	0	0	2	2	0
10	0	5	0	4	0	2	0	0	0	3	1	0	0
11	0	1	0	3	2	3	0	0	1	1	1	32	0
12	0	8	0	7	2	23	3	0	3	5	0	7	32

Search Procedures:

1. SCROLL UP
2. SCROLL DOWN
3. PAGE UP
4. PAGE DOWN
5. SECTION
6. SEARCH
7. SEARCH-AND
8. SEARCH-AND-NOT
9. INDEX
10. ZOOM IN
11. ZOOM OUT
12. FILE SELECT

Transition Matrix and Initial Profile for Cluster 6
Unspecified Tank Inventory: Nonembedded

From	To 1	2	3	4	5	6	7	8	9	10	11	12	Initial Search Profile
1	20	13	1	0	1	1	0	0	0	11	1	5	0
2	10	19	1	3	0	5	0	0	0	0	7	2	0
3	1	1	4	4	0	2	0	0	0	5	1	3	0
4	4	1	4	3	1	4	1	0	0	6	4	0	0
5	0	1	0	2	0	1	0	0	1	0	2	1	0
6	20	6	8	1	1	7	1	0	1	3	21	5	0
7	1	0	1	0	0	0	3	0	0	1	2	1	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1	2	0	0	0	0	0	0	0	4	1	4	3
10	0	10	0	7	0	21	2	0	3	11	0	0	20
11	0	3	1	8	0	6	0	0	2	3	4	20	0
12	0	8	0	6	3	23	2	0	3	1	2	3	25

Search Procedures:

1. SCROLL UP
2. SCROLL DOWN
3. PAGE UP
4. PAGE DOWN
5. SECTION
6. SEARCH
7. SEARCH-AND
8. SEARCH-AND-NOT
9. INDEX
10. ZOOM IN
11. ZOOM OUT
12. FILE SELECT

Transition Matrix and Initial Profile for Cluster 7
Equipment for APC

	To												
From	1	2	3	4	5	6	7	8	9	10	11	12	Initial Search Profile
1	24	15	0	1	0	4	1	0	0	1	1	0	0
2	9	46	1	3	0	1	2	0	2	2	1	0	1
3	0	1	6	8	0	0	0	0	0	1	4	0	0
4	0	3	11	13	1	4	0	0	1	6	2	0	3
5	0	6	1	8	3	1	0	0	2	0	2	0	0
6	12	18	9	6	0	13	0	0	2	4	5	0	3
7	8	3	0	0	0	7	24	1	0	0	6	1	1
8	0	0	0	0	0	1	0	0	0	0	0	0	0
9	4	2	2	0	4	0	0	0	0	0	2	3	0
10	0	1	0	3	3	3	4	0	0	2	4	0	6
11	0	1	1	5	3	7	2	0	2	1	2	13	0
12	0	9	0	5	13	40	20	0	12	0	9	2	94

Search Procedures:

1. SCROLL UP
2. SCROLL DOWN
3. PAGE UP
4. PAGE DOWN
5. SECTION
6. SEARCH
7. SEARCH-AND
8. SEARCH-AND-NOT
9. INDEX
10. ZOOM IN
11. ZOOM OUT
12. FILE SELECT

Transition Matrix and Initial Profile for Cluster 8
Equipment for Tank

	To												Initial Search Profile
From	1	2	3	4	5	6	7	8	9	10	11	12	
1	26	8	1	0	0	1	0	0	0	0	1	0	0
2	10	48	0	0	0	2	3	0	0	0	0	0	0
3	0	0	1	2	0	0	0	0	0	1	0	0	0
4	0	4	3	12	1	3	0	0	0	1	0	1	1
5	1	2	0	5	2	2	1	0	3	0	1	0	0
6	12	22	2	7	0	5	1	0	0	2	3	2	2
7	6	4	2	1	0	2	24	9	0	0	0	0	0
8	5	0	1	0	0	1	0	0	0	0	0	0	0
9	3	3	2	1	1	3	0	0	0	0	2	0	0
10	0	10	0	4	2	24	14	0	2	1	4	4	60
11	0	3	1	1	2	6	2	0	1	1	1	5	0
12	0	6	0	2	9	18	9	0	12	0	11	0	57

Search Procedures:

1. SCROLL UP
2. SCROLL DOWN
3. PAGE UP
4. PAGE DOWN
5. SECTION
6. SEARCH
7. SEARCH-AND
8. SEARCH-AND-NOT
9. INDEX
10. ZOOM IN
11. ZOOM OUT
12. FILE SELECT

Transition Matrix and Initial Profile for Cluster 9
Combat Support Information: Subgroups

	To												
From	1	2	3	4	5	6	7	8	9	10	11	12	Initial Search Profile
1	20	10	1	0	0	3	0	0	0	16	1	3	0
2	10	22	3	0	0	2	1	0	0	0	2	0	0
3	1	2	2	3	1	0	0	0	0	6	2	1	0
4	0	1	4	2	2	2	0	0	1	1	1	0	1
5	1	0	0	2	2	3	0	0	4	1	3	4	4
6	14	13	1	1	1	6	3	0	2	0	7	6	13
7	0	6	0	0	0	3	16	0	0	0	1	2	3
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	8	5	5	2	3	2	0	0	2	0	13	5	16
10	0	1	0	4	0	12	4	0	3	0	2	0	1
11	0	0	2	0	3	1	0	0	2	1	0	23	0
12	0	4	0	0	11	16	7	0	31	0	3	0	13

Search Procedures:

1. SCROLL UP
2. SCROLL DOWN
3. PAGE UP
4. PAGE DOWN
5. SECTION
6. SEARCH
7. SEARCH-AND
8. SEARCH-AND-NOT
9. INDEX
10. ZOOM IN
11. ZOOM OUT
12. FILE SELECT

Transition Matrix and Initial Profile for Cluster 10
Combat Support Information: Mission and Operations

From	To 1	2	3	4	5	6	7	8	9	10	11	12	Initial Search Profile
1	19	7	0	1	0	1	0	0	2	17	1	6	0
2	3	35	0	0	0	3	0	0	2	1	1	2	0
3	1	2	3	3	1	1	0	0	1	4	3	0	0
4	0	0	4	4	0	3	0	0	0	5	0	0	0
5	1	1	0	4	3	5	1	0	4	1	3	0	7
6	12	10	2	2	1	7	2	0	4	2	12	8	11
7	1	7	0	0	0	2	16	0	0	0	1	1	3
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	18	14	5	3	3	2	0	0	1	0	11	6	20
10	0	0	0	4	2	18	6	0	1	1	3	0	2
11	0	1	4	2	1	4	0	0	3	4	1	21	0
12	0	2	0	1	11	13	6	0	31	0	0	0	41

Search Procedures:

1. SCROLL UP
2. SCROLL DOWN
3. PAGE UP
4. PAGE DOWN
5. SECTION
6. SEARCH
7. SEARCH-AND
8. SEARCH-AND-NOT
9. INDEX
10. ZOOM IN
11. ZOOM OUT
12. FILE SELECT

Transition Matrix and Initial Profile for Cluster 11
Army Operations: Numerical

	To												
From	1	2	3	4	5	6	7	8	9	10	11	12	Initial Search Profile
1	2	6	0	0	1	0	0	0	0	0	0	0	0
2	1	5	0	0	0	1	0	0	0	0	4	0	0
3	0	0	5	3	2	1	0	0	1	2	4	0	0
4	1	0	5	1	1	1	0	0	0	0	1	0	0
5	1	1	1	6	2	1	0	0	2	0	3	0	2
6	3	2	0	1	0	2	0	0	2	0	5	1	7
7	0	0	0	0	0	1	1	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	2	0	4	1	1	3	0	0	1	0	7	1	14
10	0	1	0	1	1	0	0	0	1	0	0	0	1
11	1	0	0	0	3	9	0	0	4	1	0	6	0
12	0	1	0	2	4	6	1	0	7	0	3	0	12

Search Procedures:

1. SCROLL UP
2. SCROLL DOWN
3. PAGE UP
4. PAGE DOWN
5. SECTION
6. SEARCH
7. SEARCH-AND
8. SEARCH-AND-NOT
9. INDEX
10. ZOOM IN
11. ZOOM OUT
12. FILE SELECT

Transition Matrix and Initial Profile for Cluster 12
Army Operations: Verbal

	To												Initial Search Profile
From	1	2	3	4	5	6	7	8	9	10	11	12	
1	11	12	2	0	0	2	0	0	0	1	1	0	0
2	3	22	1	1	0	3	0	0	0	0	1	1	2
3	0	0	1	1	1	0	1	0	0	0	1	0	0
4	1	0	2	5	0	3	0	0	0	1	0	0	4
5	0	5	0	1	3	2	0	0	3	0	4	0	7
6	13	2	0	3	1	3	0	0	0	1	7	2	11
7	0	2	0	0	0	0	5	0	0	0	2	0	3
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	3	3	0	0	2	2	0	0	0	0	2	0	6
10	0	0	0	0	0	1	1	0	0	0	2	0	0
11	1	1	0	1	3	10	2	0	2	0	2	5	0
12	0	0	0	0	4	7	1	0	3	1	3	0	15

Search Procedures:

1. SCROLL UP
2. SCROLL DOWN
3. PAGE UP
4. PAGE DOWN
5. SECTION
6. SEARCH
7. SEARCH-AND
8. SEARCH-AND-NOT
9. INDEX
10. ZOOM IN
11. ZOOM OUT
12. FILE SELECT

Appendix M

SEARCH PLANS OF EXPERT SUBJECTS

Final Search Plan for Cluster 1
Specific APC Inventory

STEPS	SUGGESTED SEARCH PLAN
1.	FILE SELECT (to an APC inventory file)
2.	SEARCH, SEARCH AND, or SEARCH AND NOT (for specific inventory information)
3.	SCROLL UP or SCROLL DOWN (optional) (to verify or compare inventory information)

Final Search Plan for Cluster 2
Specific Tank Inventory

STEPS	SUGGESTED SEARCH PLAN
1.	FILE SELECT (to a tank inventory file)
2.	SEARCH or SEARCH AND (for specific inventory information)
3.	SCROLL UP or SCROLL DOWN (optional) (to verify or compare inventory information)

Final Search Plan for Cluster 3
Unspecified APC Inventory: Embedded

STEPS	SUGGESTED SEARCH PLAN
1.	FILE SELECT (to a APC inventory file)
2.	SEARCH (for specific inventory information)
3.	If target is not located ZOOM OUT (and repeat steps 1 and 2)

Final Search Plan for Cluster 4
Unspecified Tank Inventory: Embedded

STEPS	SUGGESTED SEARCH PLAN
1.	FILE SELECT (to a tank inventory file)
2.	SEARCH (for specific inventory information)
3.	If target is not located ZOOM OUT (and repeat steps 1 and 2)

Final Search Plan for Cluster 5
Unspecified APC Inventory: Nonembedded

STEPS	SUGGESTED SEARCH PLAN
1.	FILE SELECT (to an APC inventory file)
2.	SCROLL DOWN (for APC availability information)
3.	If target is not located ZOOM OUT (and repeat steps 1 and 2)

Final Search Plan for Cluster 6
Unspecified Tank Inventory: Nonembedded

STEPS	SUGGESTED SEARCH PLAN
1.	FILE SELECT (to an tank inventory file)
2.	SCROLL DOWN (for tank availability information)
3.	If target is not located ZOOM OUT (and repeat steps 1 and 2)

Final Search Plan for Cluster 7
Equipment for APC

STEPS	SUGGESTED SEARCH PLAN
1.	FILE SELECT (to the motorized rifle equipment file)
2.	SEARCH or SEARCH AND (for motorized rifle statistics)
3.	SCROLL UP or SCROLL DOWN (optional) (to verify or compare equipment statistics)

Final Search Plan for Cluster 8
Equipment for Tank

STEPS	SUGGESTED SEARCH PLAN
1.	ZOOM IN or FILE SELECT (to the tank equipment file)
2.	SEARCH or SEARCH AND (for tank statistics)
3.	SCROLL UP or SCROLL DOWN (optional) (to verify or compare equipment statistics)

Final Search Plan for Cluster 9
Combat Support Information: Subgroups

Steps	Description
1.	FILE SELECT (to a combat support file)
2.	INDEX (to locate subgroup information)
3.	If target is not located ZOOM OUT (and repeat steps 1 and 2)

Final Search Plan for Cluster 10
Combat Support Information: Mission and Operations

STEPS	SUGGESTED SEARCH PLAN
1.	FILE SELECT (to a combat support file)
2.	INDEX (to locate information on mission or operational capabilities)
3.	If target is not located ZOOM OUT (and repeat steps 1 and 2)

Final Search Plan for Cluster 11
Army Operations: Numerical

STEPS	SUGGESTED SEARCH PLAN
1.	Position to the army operations file (if necessary ZOOM OUT)
2.	INDEX or SEARCH (to locate personnel information)

Final Search Plan for Cluster 12
Army Operations: Verbal

STEPS	SUGGESTED SEARCH PLAN
1.	Position to the army operations file (if necessary ZOOM OUT)
2.	SEARCH (to locate specific verbal information)
3.	SCROLL UP or SCROLL DOWN (optional) (to verify verbal information)

Appendix N

INSTRUCTIONS FOR THE COMMAND-SELECTION MODELS

ONLINE ASSISTANCE INSTRUCTIONS
(Frequency-Based Advice)

In the experimental trials to follow, you will have an online assistant to help in the selection of search commands. This online assistant was developed from the performance of experienced users on this information retrieval system. Consequently, the command-selection advice offered by the assistant could be useful for finding information.

The information contained in this online assistant consists of the frequency of search procedure selection by experienced users. The online assistant will monitor your use of commands and will be able to give advice on search procedures that were used by experienced users.

Advice will be given by highlighting three search procedures on the touch keypad. These highlighted keys are the three search procedures most frequently selected by experienced users. In addition, a ranking will also be provided below each highlighted search procedure indicating the relative frequency of use by experienced users (i.e., 1 - most frequently used, 2 - second most frequently used, and 3 - third most frequently used).

As an example, Figure 1 displays command-selection advice that might be given to a subject. (Please note that Figure 1 is not presented, but a similar example is given in the body of the dissertation as Figure 9.) The online assistant has highlighted and ranked the advised search procedures in terms of selection frequency by experienced users. In this example, FILE SELECT is the most frequently selected search procedure followed by SEARCH and ZOOM-IN. Consequently, with this advice the subject might decide to use the one of these three search procedures next.

The online assistant will give command-selection advice through three different dialogues. In the first dialogue, the online assistant will give advice when you make a request by pressing a HELP key. In the second dialogue, the online assistant will decide when to give advice. Finally, in the third dialogue, you will be able to request advice and the computer will also offer advice if necessary. Only one type of dialogue with the assistant will be available during each of the three next sessions.

ONLINE ASSISTANCE INSTRUCTIONS
(Sequence-based Advice)

In the experimental trials to follow, you will have an online assistant to help in the selection of search commands. This online assistant was developed from the performance of experienced users on this information retrieval system. Consequently, the command-sequence advice offered by the assistant could be useful for finding information.

The information contained in this online assistant consists of the initial selection frequency of search commands and of the sequence of search procedures used by experienced users. For example, the online assistant knows how frequently a FILE SELECT is used as the initial search procedure and how frequently SEARCH is used after the FILE SELECT procedure is selected. Therefore, the online assistant will monitor your use of commands and will be able to give advice on what search procedures to use considering the search procedure selected previously.

Advice will be given by highlighting three search procedures on the touch keypad. These highlighted keys will be the three search procedures most frequently selected by experienced users either initially or considering a previous search command (depending on whether advice is given at the start or in the middle of a trial). In addition, a ranking will also be provided below each highlighted search procedure indicating the relative frequency of use by experienced users. (i.e., 1 - most frequently used, 2 - second most frequently used, and 3 - third most frequently used).

As an example, Figure 1 displays command-sequence advice that might be given to a subject after the selection of the FILE SELECT procedure. (Please note that Figure 1 is not presented, but a similar example is given as Figure 10 in the body of the dissertation.) The online assistant has highlighted and ranked the advised search procedures in terms of frequency of selection by experienced users. In this example, SEARCH would be the most frequently selected search procedure after the selection of the FILE SELECT procedure, followed by SEARCH AND and SCROLL DOWN. Consequently, with this advice the subject might decide to use one of these three search procedures next.

The online assistant will give command-sequence advice through three different dialogues. In the first dialogue, the online assistant will give advice when you make a request by pressing a HELP key. In the second dialogue, the online assistant will decide when to give advice. Finally, in the third dialogue, you will be able to request advice and the computer will also offer advice if necessary. Only one type of dialogue with the assistant will be available during each of the three next sessions.

ONLINE ASSISTANCE INSTRUCTIONS
(Plan-based Advice)

In the experimental trials to follow, you will have an online assistant to help in the selection of search commands. This online assistant was developed from the behavior of experienced users on this information retrieval system. Consequently, the command-selection advice offered by the assistant could be useful for finding information.

The information contained in this online assistant consists of the sequence of search procedure use by experienced users, as well as some information on target characteristics. For example, the online aid knows the most frequently used sequence of search procedures for a class of targets. Therefore, the online assistant will monitor your use of commands and will be able to give advice on what search procedures to use. In addition, it will provide information on what target characteristics to look for during information retrieval. Together, the sequence of search procedures and the target characteristics define what will be called a search plan.

Advice will be given by displaying the search plan in the work area of the primary display and highlighting the appropriate search procedures on the touch keypad (see Figure 1). (Please note that Figure 1 is not presented, but a similar example is given in the body of the dissertation as Figure 11.) The search plan may be two or three steps long and may contain one, two, or three alternative search procedures in each step. The numbers below each of the highlighted search procedures on the touch keypad correspond to the step in the search plan.

As an example, Figure 1 displays a search plan for finding a target. This search plan directs the subject to use the FILE SELECT procedure to position to a tank inventory file, followed by a SEARCH or SEARCH AND procedure to find specific inventory information. Finally, an optional SCROLL UP or SCROLL DOWN step is listed to verify or compare inventory information.

The online assistant will give plan-based advice through three different dialogues. In the first dialogue, the online assistant will give advice only when you make a request by pressing a HELP key. In the second dialogue, the online assistant will decide when to give advice. Finally, in the third dialogue, you will be able to request advice and the computer will also offer advice if necessary. Only one type of dialogue with the assistant will be available during each of the three next sessions.

Appendix O

INSTRUCTIONS FOR THE DIALOGUE INITIATIVES

COMPUTER-INITIATED ADVICE

In this dialogue with the online assistant only the computer will determine when to give advice on the selection of search commands. That is, the online assistant will monitor your selection of search commands and give advice if it determines that you are using search procedures unlike experienced users.

When giving advice, the online assistant will highlight and rank the search procedures most frequently used by experienced users. The online assistant will only give advice once during a trial, and once presented, the advice will remain on the display. In addition, it is important to note that the online assistant will cancel the search procedure you selected when providing advice. You can, however, select the cancelled search procedure again after the advice is given.

We would like to encourage you to try to use the command-selection information given by online assistant since it will probably be useful for assisting and improving your information retrieval skills. However, please remember that just like a human assistant, the online assistant may sometimes provide inappropriate advice.

If you have any questions at this time, please ask the experimenter.

USER-INITIATED ADVICE

In this dialogue with the online assistant you will have a HELP key to request command-selection advice. The HELP key is the large key on the right side of the keyboard.

In response to your pressing the HELP key, the assistant will highlight and rank the search procedures most frequently used by experienced users. You can request advice at any time during the trial, however, once advice is presented it will remain for the rest of the trial.

We would like to encourage you to try to use command-selection information available through the online assistant since it will probably be useful for assisting and improving your information retrieval skills. However, please remember that just like a human assistant, the online assistant may sometimes provide inappropriate advice.

If you have any questions at this time, please ask the experimenter.

COMPUTER- AND USER-INITIATED ADVICE

In this dialogue with the online assistant you will have a HELP key to request command-selection advice. The HELP key is the large key on the right side of the keyboard. You can request advice at any time during the trial. In addition, the online assistant will also be monitoring your selection of search commands and will indicate when it has advice available by displaying the highlighted message "If you want advice press HELP" directly below the touch keypad.

In response to your pressing the HELP key, the assistant will highlight and rank the search procedures most frequently used by experienced users. This advice will then remain on the display for the rest of the trial.

We would like to encourage you to try to use command-selection information available through the online assistant since it will probably be useful for assisting and improving your information retrieval skills. However, please remember that just like a human assistant, the online assistant may sometimes provide inappropriate advice.

If you have any questions at this time, please ask the experimenter.

Appendix P

INSTRUCTIONS AND PRACTICE FOR THE BIPOLAR ADJECTIVE SCALES

INSTRUCTIONS

At this time we would like you to evaluate the file search assistance that you received during this session. To evaluate the file search assistance, 12 scales with two adjectives will be presented, one scale at a time. The first scale you will receive will be an overall evaluation of the file search assistance. This overall scale will be followed by 11 individual scales for evaluating the assistance.

Your task will be to rate the assistance using the two adjectives on a seven-point scale. To demonstrate, an example will follow asking you to evaluate your last vacation.

(All subjects would then receive the overall satisfaction scale and two individual bipolar scales. Therefore, the three bipolar adjectives that subjects would practice by evaluating their last vacation were:

1. UNSATISFACTORY-SATISFACTORY
2. HECTIC-RESTFUL
3. HEALTHY-UNHEALTHY.)

Appendix Q

FORM FOR COLLECTING THE DIALOGUE PREFERENCE RANKINGS

Please rank order the online assistance dialogues from 1 to 3.

1 - signifies your most preferred dialogue and 3 - signifies your least preferred dialogue.

_____ Computer-Initiated

_____ User-Initiated

_____ Mixed-Initiated

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A BEHAVIORAL EVALUATION OF COMMAND-SELECTION AIDS FOR INEXPERIENCED COMPUTER USERS

by

Jay Elkerton

(ABSTRACT)

Two experiments were conducted to determine the feasibility of providing online command-selection aids to novice users of an information retrieval system. The results of the first experiment revealed a difference in the mean and variability of search performance between novice and expert computer users. Half of the novices were performing much like experts, while the rest of the sample was extremely slow. These slower novices were using inefficient scrolling strategies and appeared to be unfamiliar with the structure of the database.

The second experiment evaluated whether novices could be assisted or trained with command-selection aids developed from the behavior of experts. The command-selection aids were defined in a 3 X 3 mixed factor design with type of model (frequency, sequence, or plan-based) as the

between-subjects variable and dialogue initiative (user, computer, or mixed) as the within-subjects variable. The frequency and sequence models presented and ranked search procedures based on a command-usage profile and a command-transition matrix, respectively. The plan-based model presented an ordered set of search procedures with verbal explanations. All models were constructed for groups of homogeneous search problems selected by a sorting and cluster analysis. The three dialogue-initiatives determined whether the user, the computer, or both the user and computer controlled presentation of advice. Administration of the dialogue initiatives was completely counterbalanced and was followed by a final unaided transfer session.

As a result of receiving online aiding, the wide ranging search performance of novice subjects was improved both during assistance and transfer. Performance of aided novices was superior to the slow novices and equal to the fast novices and experts. All three command-selection models were equally effective, with exception of the sequence model which sometimes presented frequent and complicated advice. Of the dialogues, mixed-initiated advice was ineffective during the first aiding session possibly due to the difficulties novices faced deciding whether to receive the suggested assistance. The conclusion of the study was that online command-selection aids can be effective if providing appropriate feedback and minimizing the amount of dialogue in aiding.