The Investigation of Online Manuals and the Role Guidelines Abstraction has on the Usefulness of Interface Design Guidelines in the Evaluation of User System Interfaces

by

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(ABSTRACT)

User system interface guidelines are emerging as a tool for user interface design. However, guidelines are relatively new, and the effectiveness of guidelines in their present form is still being debated. Some designers of USI tools are attempting to place guidelines online in browsing systems, often as a part of automated USI design tools. This thesis studies the role levels of abstraction has on the detection of USI guidelines violations in user interface evaluation. Studies of online guidance systems, such as help manuals, have yielded mixed results in comparing performance when using online systems versus hardcopy manuals. This thesis also explores the effect which guideline presentation media has upon guidelines usage.

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INTRODUCTION

Within the last decade, user-system interface (USI) design has been receiving greater design resources and attention than what had been previously allocated. Early software design methodologies often heavily stressed the application package, with the USI tacked on as an afterthought. More often than not, the result was powerful application software package that was frustrating and/or time consuming to learn and to use. User performance was compromised due to USI design deficiencies.

Major foci in the research in USI design include expansion of the USI knowledge base and the development of tools such as rapid prototyping and USI guidelines. There is extensive work being done in applying human factors research to produce USI guidelines. It is hoped that guidelines can facilitate the application of human factors knowledge to the actual design process to produce more effective, performance-maximizing interfaces.

An issue that needs to be addressed is the effect of the media in which the USI knowledge base will be presented. Currently, there are several manuals that contain USI guidelines, the most extensive being Smith and Mosier's (1984)

collection of over 600 guidelines. These manuals are predominantly available in hardcopy (reference manual) form, although work is being done to place them online as automated design tools. The question remains, however, whether there is justification for placing technical guidance information online.

This thesis explores the role of guidelines in the evaluation of USIs. The criticism that many existing guidelines are too general and abstract for practical application by software designers is addressed by looking at the ability of potential software engineers to evaluate interfaces and detect guideline violations in USI prototypes. Not only is the effect of using guidelines in the evaluation process assessed, but question of which presentation medium, online or hardcopy, is more effective is also examined.

THE USI DESIGN TASK

The Goal of USI Design

The goal of USI design is to make software compatible with its user. This compatibility is measurable by five human factors (Schneiderman, 1986):

- learning time--the time it takes for a typical target user to learn, to a specified level of proficiency, how to use the commands relevant to a set of tasks.
- performance speed--the time it takes to complete a bench-mark set of tasks,
- error rate--the number and types of errors made in carrying out a bench mark set of tasks,
- retention--how well users maintain their knowledge of the system after a specified length of time, and
- subjective satisfaction--the subjective impression of the users after using the USI. The term "user friendly" can best be associated with this factor.

The goal then is to minimize learning time, performance time, and error rate and to maximize retention and subjective satisfaction. USI design is a complex procedure which does not necessarily allow optimization of an interface along all five factors. Considering that human diversity has to be accounted for, USI design is a heuristic, often interative process that forces tradeoffs to create the most acceptable interface.

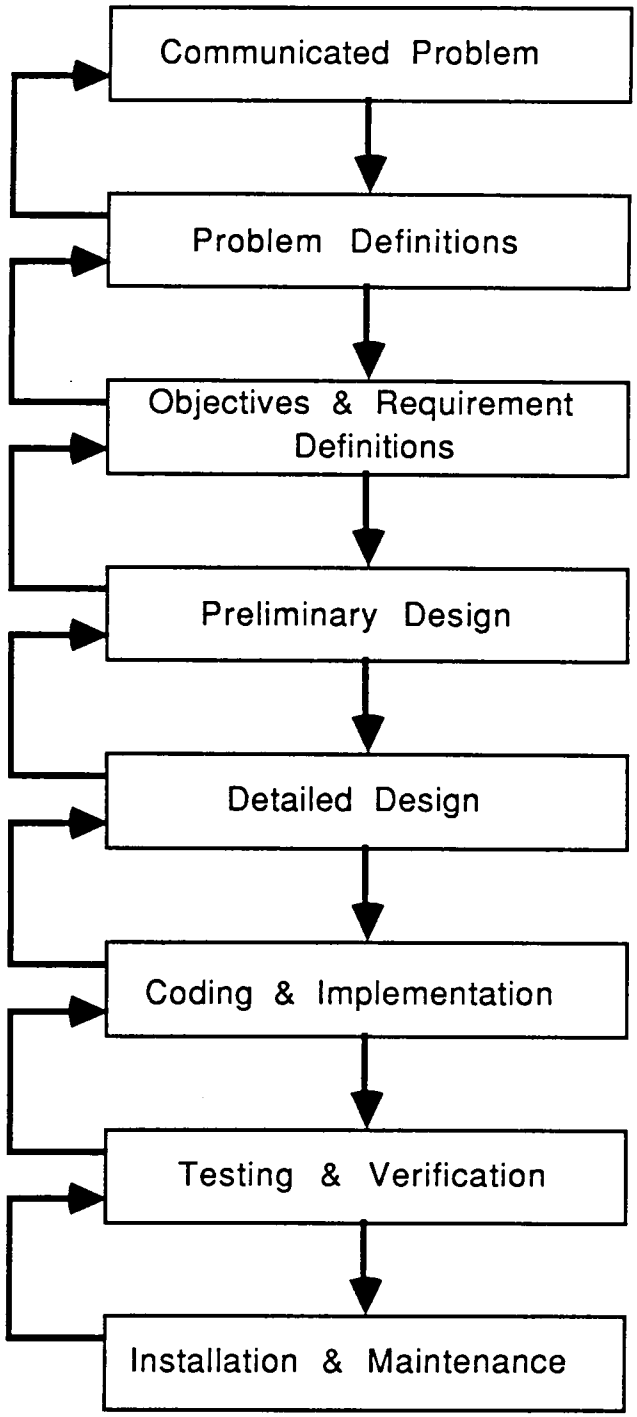
Deficiencies in USI design can result in degraded system performance. At one extreme, the deficiencies may result in disruptive consequences and data loss or even the user's abandonment of the system due to frustration. Because people

are adaptive, rarely will any single USI design flaw, by itself, cause a system to fail. However, there is a limit to how well users can adapt or are willing to to a poor system. The cumulative effects of multiple deficiencies may result in poor performance, system failure, or user rejection.

The Software Design Lifecycle

The design process is, in a broad sense, problem solving. But to say only that design is problem solving provides a woefully inadequate model of the cognitive processes involved. Figure 1 shows a conventional model of software design which follows a lifecycle approach with distinct stages of development (Joshi, 1983). This model fails to show the importance of early design specification and iterative redesign and testing. Only an estimated 25% of the defects in a software system results from incorrect coding (Peters, 1981). Since the coding stage is only one step, and generally the shortest of the software development lifecycle depicted in Figure 1, the value of optimizing the other stages is readily apparent.

A more recent model operationally defines design as a sequence of steps that allows iteration and recursion, provides for identifying phases of design, and provides a framework for empirical testing of specific hypotheses (Malhotra,



gure 1. Stages of the software development lifecycle (Joshi, 1983).

Thomas, Carroll, and Miller, 1980). Emphasis is placed on system development before any attempt is made at coding. The iterative nature of the software design process is fully illustrated in Figure 2 (Williges, Williges and Elkerton, 1987).

Recent approaches to USI design have been to include the end users and USI human factors experts on the design team in a multi-disciplinary approach. It was found that it is possible to create systems designed by and for users with increased levels of usability and functionality. The level of involvement of the end users and the human factors experts varies from system to system. Ideally, the end users of the system should participate throughout the entire system development lifecycle.

At the minimum, the end-user should be involved in the design process at an early stage in creating design specifications. Data from a study of design suggestions made by end users to system designers in the development of Eve, an interface for VAXTPU, show that early suggestions were incorporated more frequently in the design than were later suggestions (Good, 1985). On a more prosaic level, minimizing design flaws in the early stages of development can substantially reduce costs and the need for extensive redesign. As the USI develops, it becomes progressively harder to make major changes

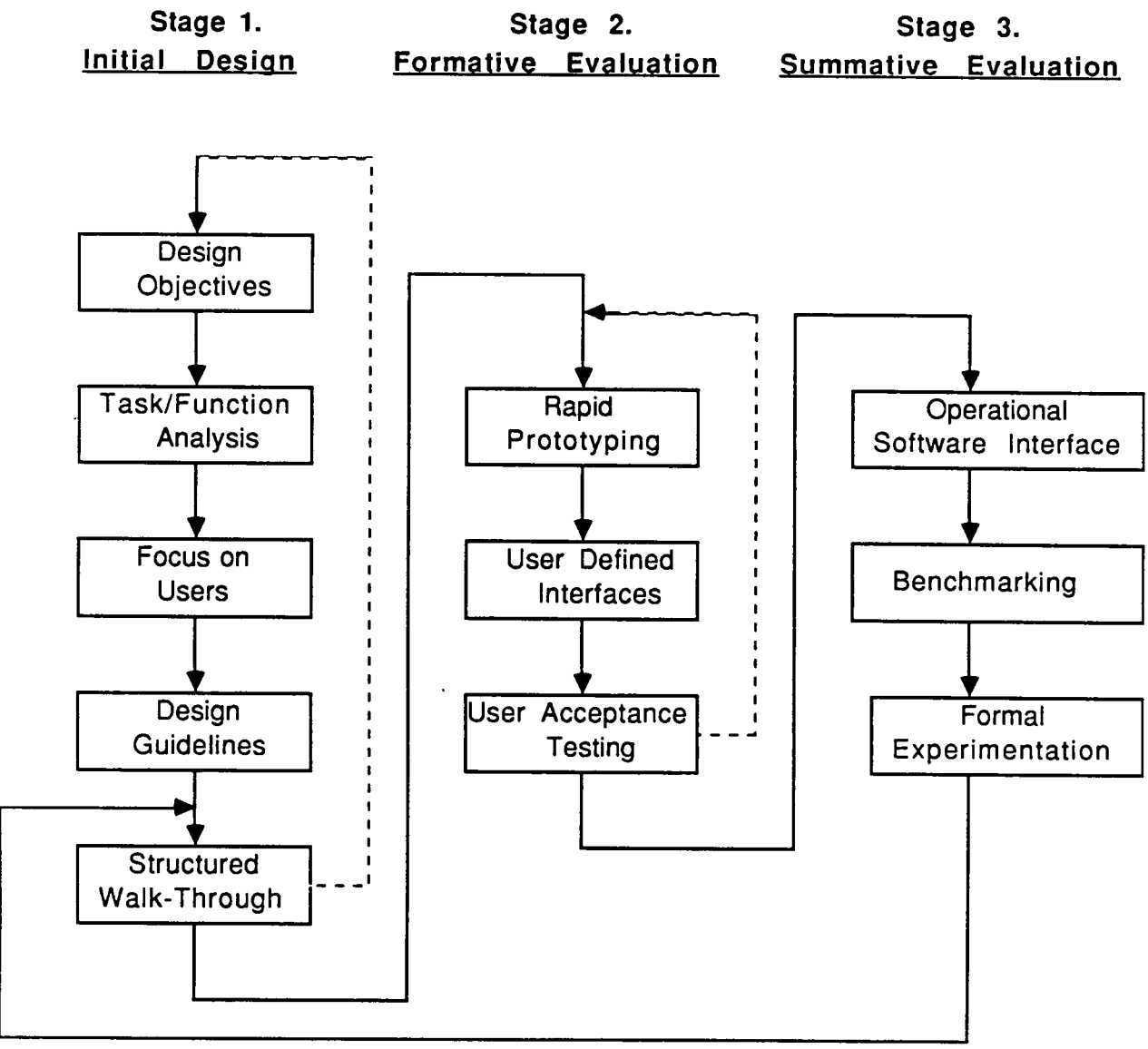


Figure 2. Three stages of iterative software interface design (Williges, Williges and Elkerton, 1987).

(Peters, 1981). As the USI approaches final design and implementation, even seemingly "minor" changes become increasingly difficult to make.

Cohill, Harper-O'Donnell and Curran (1985) found that end users with little grasp of the technology available to them tended to want the new system to be just like the old ones with which they were familiar, even to the extent having the same problems. Users cannot be expected to evaluate a technology that they have not used (Shackel, 1984).

Often, it is the role of the system designer to create, from a list of general specifications, the first draft or prototype of the user interface. Once a prototype has been built, the software designer, with the help of the end users, can tune the interface through a series of iterative refinements. But the programmer or designer also suffers from reliance on using experientially derived stereotypes, practicing the philosophy of what worked once will work again. A study of training device designers indicated that personal experience was helpful 17% of the time compared to approximately 9% for human factors experts and 10 % for human factors data. Exposure to similar or analogous systems was rated as helpful 29% of the time (Klein and Brezovic, 1986).

USI GUIDELINES

USI Guidelines Target Users

The average software designer can not be expected to perform unaided as his or her own USI specialist, nor analyze a design to the degree necessary to apply all relevant human engineering criteria (Meister and Farr, 1967). System designers are typically trained in computer science or engineering, yet they must address complex human factors problems and the psychology of the user in designing the user interface with which users may interact (Tijerina, Chevalaz, and Myers, 1985). The ideal solution is to include USI experts in the design task. Having the end-user and HCI experts in the design process is an important fundamental aspect of USI design. However, for one reason or another, this may not be feasible. In the industrial world, the cost of including end-users and HCI experts often limits their participation to the role of specifiers and design reviewers. Also, the need for HCI experts still outweigh the number of available professionals.

The average software engineer, especially one just entering the job market, has little or no understanding of human factors as applied to software. Computer science has typically stressed applications programming, and has largly neglected

the issue of USI design. It is left to the engineer to learn USI principles on his or her own.

It seems obvious that a readily packaged distillation of human factors expertise could be invaluable to USI specialists and designers alike. The results then are compilations of the knowledge base into USI human factor guidelines.

The Knowledge Base of USI Guidelines

The knowledge base of USI design information is constantly expanding. Several attempts have been made to collect the vast array of information into guidelines that are usable as design aids by software designers (Smith and Mosier, 1984b; Stoddard, 1985). Compilation of USI design information into guidelines seems inherently attractive. However, USI guidelines have met with mixed reactions. Serious questions are being asked about the usefulness of the guidelines in actual design (Mosier and Smith, 1985).

The emphasis among developers of human factors guidelines has been to create guidelines of high quantitative precision. However, two conditions have to be met for such guidelines to be satisfactory. First, there must be an extensive collection of raw quantitative data as a base upon which to build the guidelines. Second, the design specifications for

which the guidelines are to be used must be explicitly identified, something which is atypical of USI design (Ramsey and Atwood, 1980).

Current guidelines borrow heavily from a core set of materials developed 5-10 years ago. Guidelines are not built upon a strong foundation of empirical knowledge, but instead upon practical experience, tradition, common sense, intuition, and general principles of human performance. Recent innovations in USI have been icons, graphics, multiprocessing, multiple windows, and new input devices. However, the guidelines set for these new aspects of USI are lacking (Tijerina, Chevalaz, and Myers, 1985).

In some well established research areas, primarily those dealing with keyboard design and the physical properties of displays, reasonably good and detailed guidelines already exist. These guidelines are helpful in the design of the physical workstation. However, for other central issues in interactive systems, such as their basic informational properties, user aids, and dialogue methods, available guidelines become sketchy and vague. Furthermore, where guidelines deal with cognitive or behavioral issues, they tend to be highly qualitative and open to individual interpretation, and therefore individual implementation (Granda, 1980). These issues have only recently been approached using cognitive

models, reflecting the increased use of interactive systems to support cognitive tasks (Ramsey and Atwood, 1980).

The human factors principles can be broken down into hardware and software guidelines. These can be further classified according to the specific type of task or system application, such as text editing or graphics/ drafting, to which they apply. Subordinate to applications are functionalities such as data entry, data display and the other major categories of the Smith and Mosier (1984) guidelines. Within each of these distinctions, software guidelines can be found which vary in terms of their generalizability. This generalizability can be thought of as a continuum having concrete (usable as is) and abstract (written with a level of generality that requires the designer to interpret the guideline to his or her needs) as its end points.

Quantifiable guidelines usually are located toward the extreme, concrete end of the spectrum. Certain qualitative guidelines that make a specific statement, such as "In multi-paged displays, label each page to show its relation to the others," also can be found near the concrete end. The qualitative guidelines that require some level of translation on the part of the designer are found at the abstract end of the spectrum. They require the user to make judgements and assumptions, either about the system or the cognitive proc-

esses of the end users. Figure 3 depicts such a taxonomy and hierarchy of USI guidelines, and Table 1 lists definitions of the various categories found in the hierarchy.

In the taxonomy shown in Figure 3, the guidelines are broken down into several levels. At the highest level, USI can encompass very broad principles of USI design such as the seven in Table 2 suggested by Williges, Williges and Elkerton (1986). This broad, meta-view of USI design is most valuable in sensitizing the designer to human factors issues and is abstract enough not to be constrained by the quasi-specificity of guidelines. The user does not have to interpret and apply guidelines that attempt, but fall short, of specifying how or when to apply them.

Guidelines Usability

A common criticism made by designers is that several guidelines may make different, sometimes conflicting, recommendations about an aspect of USI. The designer is left with the task of making a trade-off analysis, usually with no information on which to base his or her decisions (Mosier and Smith, 1985).

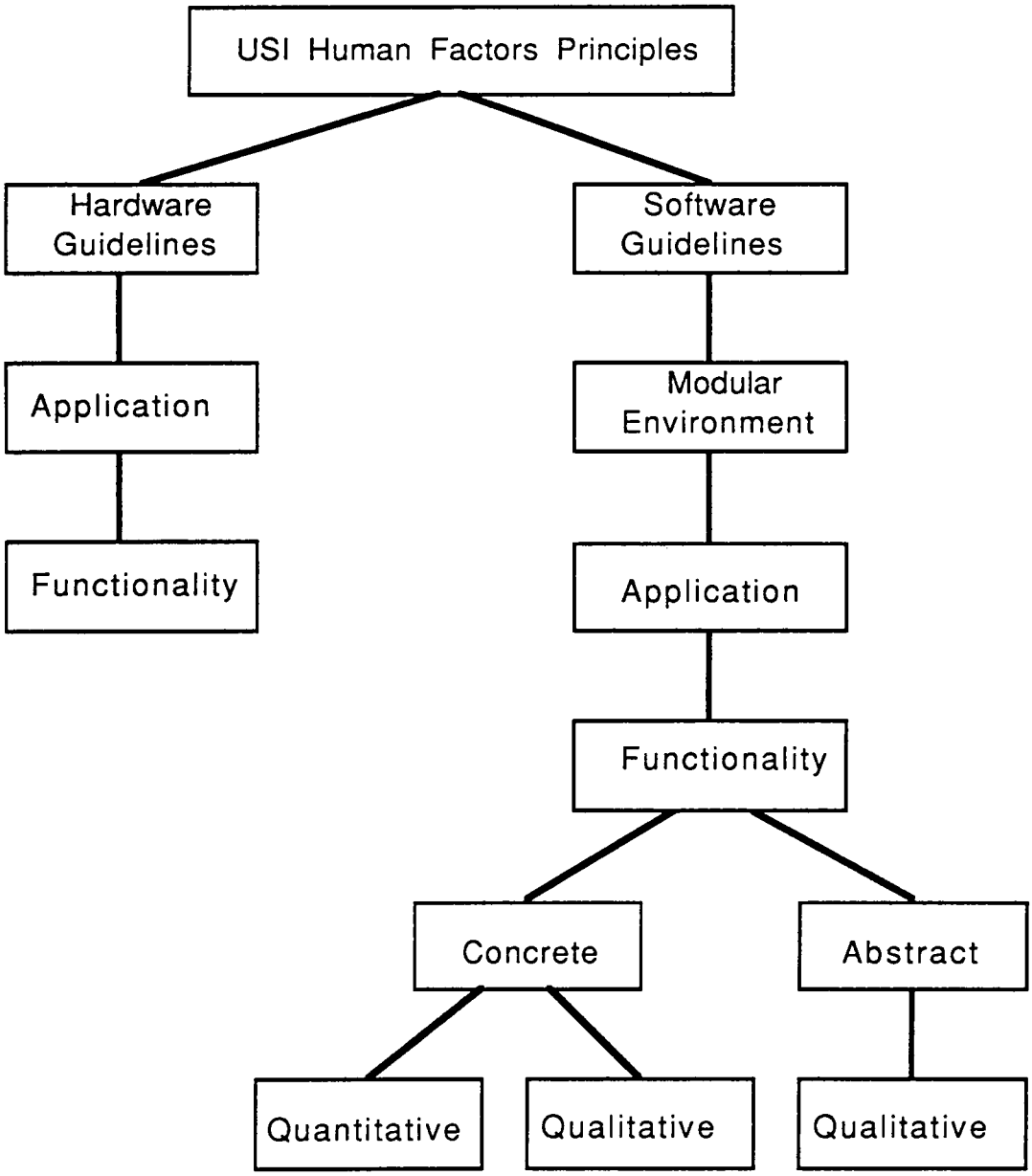


Figure 3. Taxonomy and hierarchy of USI Guidelines

Table 1. Definitions of the categories in Figure 3.

Category	Definition
USI Human Factors Principles	Gestalt principles of USI, i.e., the 7 principles of Williges, Williges and Elkerton (1986).
Hardware guidelines	USI guidelines that help define what hardware is required for an optimal system.
Hardware Application	USI applications may induce hardware constraints.
Hardware Functionality	USI hardware guidelines may be grouped according to certain functions such as data entry or data display,
Software Guidelines	USI guidelines applicable to software.
Modular Application	Guidelines applicable to the software's operating environment.
Software Application	Certain USI software guidelines which may be particularly relevant to certain applications.
Software Functionality	USI software guidelines which may be grouped according to certain functions such as data entry or data display.
Concrete	Guidelines that make statements which can be used in direct application and are specific enough not to require designer's interpretation.
Abstract	Guidelines with a level of generality requiring the user to make assumptions or define boundaries to translate the guidelines into usable forms.
Quantifiable	Guidelines that have specific numeric values or ranges attached to them.
Qualitative	Guidelines that have no numerical value attached to them.

Table 2. Seven Principles of human-computer interface design

(Williges, Williges, and Elkerton, 1986).

Principles	Definitions
Compatibility	Minimize the amount of information recoding that will be necessary.
Consistency	Minimize the difference in dialogue both within and across various human-computer interfaces.
Memory	Minimize the amount of information that the user must maintain in short-term memory.
Structure	Assist the users in developing a conceptual representation of the structure of the system so that they can navigate through the interface.
Feedback	Provide the user with feedback and error correction capabilities.
Workload	Keep user mental workload within acceptable limits.
Individualization	Accommodate individual differences among user through automatic adaptation or user tailoring of the interface

A study by Mosier and Smith (1985) of designers' usage of USI design guidelines revealed that guidelines can be and are used. However, in their study, they found that subjects (comprised of software designers, human factors specialists, system analysts, system engineers, managers, teachers, and students) use less than 40% of the guidelines. They also

found that software designers rated the guidelines as less useful than non-designers.

That software designers rated guidelines as less useful than non-designers can be readily understood. One of the most common criticisms of USI guidelines is that they are too general to be applied. An example of one such guideline is "Tailor the display of data to user needs, providing only necessary and immediately usable data at any step in a transaction sequence" (Smith and Mosier, 1984). The designer is left with the dilemma of determining what is necessary and immediately usable data. For a designer who must eventually deal in exact measures and terms, the generality can be extremely irritating.

An estimated 20% of the Smith and Mosier (1984) USI design guidelines can be used as written, prompting criticism by designers that the guidelines are for, and are only usable by human factors specialists. Of these, even fewer guidelines are quantitative. Most guidelines are qualitative, although they differ significantly in specificity.

Some of the problems associated with guidelines can be derived from the way the guidelines are used. As Smith (1980) noted, the general guidelines must be translated into specific rules that a designer can follow. This involves con-

sidering the guidelines not as a set of standards but as design recommendations. A criticism leveled at USI guidelines is that specific data useful to a designer are often lost in the bulk of more general data (Tijerina, 1986). The applicable guidelines must be gleaned from the larger set of often conflicting or contradicting guidelines. Judgement must be used to apply these recommendations to the specific application. Thus, applying the guidelines is more than finding a guideline in a book and using it. Smith alludes to the application of guidelines as a translation into design rules, much as the overall course of system development is a series of translations from operational need into defined functional requirements, from requirements into design specifications, and from specifications into component designs at various levels. Ramsey and Atwood (1980) suggest that what is needed is a guide to proceduralized design. This proceduralized approach can guide the designers in a top down methodology , defining for him or her what guidelines are applicable and can be used. They also suggest that guidelines may be better if written for specific types of systems, rather than for interactive systems in general.

USI Design Standards

There has been growing interest in the establishment of design standards for both hardware and software components of

the USI, especially by the military. Design standards differ from guidelines in that they are a series of generally stated requirements (instead of recommendations) imposed in some formal way. They are prescriptive rather than descriptive.

In 1987 the USI Department of Defense expanded MIL STD 1472-C, its Human Engineering standards to include 9 pages devoted to "Personnel-Computer Interface standards, with more expected. The German Institute of Standards (DIN) has also proposed a standard for USI design (Smith, 1985). Within the Human Factors Society, the Human-Computer Interface Committee (HFS HCI Committee) is exploring the feasibility and desirability of adopting a set of human-computer interface standards or guidelines (Reeds, 1986).

Several benefits result from adoption of industry-wide standards. Encouraging the application of research-based standards should result in the design of better interfaces. Also, the widespread adoption of standards should result in increased consistency of user interfaces across various software systems. The training time for each system is minimized due to increased transfer. The standards should also reduce system development time and cost since much of the USI design will be cook book driven (Reeds, 1986).

However, standards suffer from many of the problems that are presently inherent in USI guidelines. They may be difficult for software designers to consistently interpret and apply; and will, therefore, not ensure the development of consistently good designs. Furthermore, standards may force the designers to follow design paths that may be inappropriate for his or her design. Also, standards may discourage or preclude creative research and may in fact delay advances in the state of the art. Generally, standards are only enforceable when considering physical characteristics, such as number of colors on the display, or in hardware configurations. Psychology is the fundamental basis for most USI software standards, and what psychological knowledge that has been garnered is difficult to translate into design standards (Smith, 1985).

The HFS HCI Committee found that the set of standards proposed by DIN was more a collection of guidelines than usable standards. They suffered from a number of deficiencies including no distinction among different types of software, users or hardware; vague, imprecise wording; and no objective procedures for determining conformance to the stated standards. These problems have to be addressed before effective user system interface standards can be developed (Reeds, 1986).

Improving Guidelines Usability

The HFS HCI Committee has proposed a standards development methodology for specifying the applicability of USI guidelines. The methodology includes stating specific selection criteria for each guideline, discussing the advantages and disadvantages for each guideline, specifying a confidence rating based on the type of evidence which led to the guideline, and specifying procedures for evolving the guidelines as new technology and behavioral data become available (Reeds, 1986).

Tijerina (1986) also suggests four features to enhance the usability of guidelines. These include the addition of decision aids that will tell the designer which of several guidelines are particularly relevant for a given type of application, ranking relative importance for each guideline to help resolve conflicts among guidelines, cross-referencing guidelines which address the same feature, and using an organizational scheme keyed to the design process and using designer's terminology.

ONLINE VS. HARDCOPY: GUIDELINE PRESENTATION MEDIUM

Online Information System

Guidance information can be presented to the USI designer in a myriad of different ways. RIPL (Lenorovitz and Reaux, 1986) attempts to capture the information in three different ways: an online user-accessible reference library containing the Smith and Mosier (1984) guidelines, a baseline ability to evaluate and assess prototyped dialogues within selected USI design parameters, and a consultation expert-system. Smith and Mosier are themselves working on placing their guidelines online in an interactive browsing system (Mosier and Smith, 1985). The more traditional database structures can also be used, as well as the more common medium of a hardcopy reference manual/textbook.

The underlying concept of the online user manual is to provide the user with the electronic analogy of an online textbook (Lenorovitz and Reaux, 1986). This differs from the traditional approach to data management, i.e., databases, in that the organizational structure of the data not only allows for the look up of specific data entries through the use of a table of contents or index, but also allows the user to browse through relevant content material that he or she wishes to see. The power of the browsing approach is par-

ticularly important to designers since they themselves often do not know specifically which guidelines they will need.

The architecture of a browsing online system such as RIPL's Technical Librarian (TL) captures the fundamental power of database management systems, as well as the power inherent in the hardcopy textbook medium. As a database management system (DBMS), the TL can allow cross referencing, much as the traditional "join" commands in DBMSs. The data can be arranged in hierarchical or network manner using technology already developed from DBMSs. However, the TL retains much of the characteristics of the hardcopy manual, such as the functional utility of the table of contents, the cross-referenced index, the browsing capability, and the ability to mark certain "pages" for future use. The TL fits most people's mental model of a textbook much more readily than does a traditional DBMS.

Putting information in an online manual allows for greater flexibility in what is presented than if it was presented in hardcopy form. With an online system, graphic or tabular information such as guideline implementation examples can be dynamic. Guidelines pertaining to dynamic processes, such as sequence control, can also be demonstrated. In effect, the online reference can be coupled with short user-interactive software modules--prototypes (Lenorovitz and

Reaux, 1986). Within a multi-sharing environment, the online document can be accessed and used by several people. Additionally, the computer's excellence in doing searches, such as string or key-word searches or cross-indexing, can be fully exploited. Finally, the online technical manual can be integrated with other software tools, such as a rapid prototyping tool, to form a unified software design package.

Effectiveness of Online Information Systems

Although some research has been conducted on the effectiveness of using online HELP manuals (Price, 1982; Cohill and Williges, 1982), very little work has been done in studying the effectiveness of using other online information. Some studies indicate that reading speed could be as low as 50% slower if reading from a CRT screen than from paper. However, the reading speed for using a CRT could be optomized to make reading from CRTs as effecient as from paper. The display characteristics, such as resolution, view window, contrast, as well as the fonts and even polarity can affect reading speed (Gould, Alfaro, Finn, Haupt, Minuto, and Salaun, 1987).

The data on online HELP systems indicate that for novice users, hardcopy manuals are more effective than online systems for the retrieval and implementation of HELP information

(Cohill and Williges, 1982). This finding may be uniquely attributable to the nature of the HELP information retrieval task. The information sought is usually directly relevant to the running of the software system, and much of the information is syntactic rather than semantic.

Online documentation is used by people who need rapid access to the few facts that will enable them to perform a specific task (Price, 1982). A study by Weldon, Mills, Koved and Schneiderman (1985) indicates that although people were faster at switch setting tasks when using hardcopy technical manuals than when using online manuals, in subjective evaluations, they rated online manuals as better and more organized than paper manuals. Work, such as the following research, must therefore be done to consider the merit of placing non-HELP technical manuals online.

RAPID PROTOTYPING

Rapid Prototyping in the USI Design Lifecycle

A tool that evolved from the iterative software design process is rapid prototyping. Rapid prototyping, coupled with USI design guidelines, can be a powerful composite tool for effective USI design. It enables user interfaces to be created, demonstrated, evaluated and modified in a

proceduralized manner at a point very early in the design development process.

Fundamentally, a rapid prototyping tool is a software package that allows the creation of interfaces that are easily modifiable (in effect a macro language of procedures and routines). As is evidenced by the plethora of rapid prototyping software packages that have been or are under development, such as AIDE (Hix and Hartson, 1986), MENULAY (Buxton, Lamb, Sherman, and Smith, 1983), RIPL (Lenorovitz and Reaux, 1986), and ACT/1 (Mason and Carey, 1983), rapid prototyping can and will substantially impact USI design, truly allowing it to be an iterative process. The design task then becomes a cyclic process of base-line design, followed by USI prototype modeling and simulation, interface testing and evaluation, and iterative refinement (Lenorovitz and Reaux, 1986).

Rapid Prototyping as a Communication Tool

Textual description has been the traditional communication channel between the designer and the user. Its major disadvantage is the psychological distance between itself and the interface. Prototyping alleviates the need for the user's symbolic understanding of the design. Because rapid prototyping allows the direct translation of design characteristics or specifications into a working interface, the user

has a first hand and relatively realistic operational representation of the interface. (Mason and Carey,1983). The goal is to fine tune the interface characteristics based upon USI design principles and on user responses.

As with most prototyping tools, such as RIPL (Lenorovitz and Reaux, 1986) and ACT/1 (Mason and Carey, 1983), the prototypes built are usually not the final interface. Instead, the prototypes are generally simulations built and run within a development environment and are not production versions of a system. However, with some independent dialogue systems such as AIDE, (Hix and Hartson, 1986) the resulting prototypes are intended to be grafted directly onto an application.

Rapid Prototyping and the End User

Rapid prototyping tools allow USI designs to become visible and modifiable early in the system development process. Although many of the environmental characteristics, such as system response time, may not be known and therefore simulated in the prototype, the USI can facilitate the detection and resolution of major USI problems early in the design and development cycle (Lenorovitz and Reaux, 1986). At the least, the prototypes will have a large degree of face validity. By exposing the end users to such prototypes, valu-

able performance or subjective feedback data can be obtained from the users. In effect, the proposed USI can be tested and evaluated long before it is implemented.

Prior to the creation of design tools, the evaluation of interfaces was primarily a summative event. Although textual descriptions of the interface, and even pen and pencil graphical snapshots of the interface, could and were used in formative evaluation, they did not have the power of prototyped interfaces. Prototyping tools do not eliminate the need for summative evaluation, but shift the emphasis to formative evaluation within the design process. As was previously mentioned, the earlier in the design process that feedback is obtained from the user, the easier and more probable that changes can and will be made in the design.

USI Guidelines Embedded in Rapid Prototyping

Recent work has explored the possibility of integrating USI guidelines into prototyping tools, either as an integrated online database that one can use to create or evaluate the interface, or embedded in the prototyping software itself. RIPL is a package that attempts to do both. Not only does it contain an online browsing system containing the Smith and Mosier USI guidelines (1984), but it also has an artificial intelligence package which can make USI design suggestions.

A future enhancement for RIPL is to record metrics from a prototype and compare the metrics to standards distilled from USI guidelines, flagging potential problem areas in the interface for the designer (Lenorovitz and Reaux, 1986).

Integrating a prototyping tool with a online guidelines system offers a new means of communicating USI issues. Examples of good and bad USI elements can be embedded in prebuilt mini-prototypes that the guidelines users can run and analyze. A hardcopy manual only allows static examples of given aspects of a dynamic USI. Although the system used in the experiment did not, an online system can offer the advantage of providing interactive examples, With dynamic interactive examples, the guidelines user can explore the effects of user entries upon a USI.

PURPOSE

The knowledge base of USI design information is constantly expanding. Several attempts have been made to collect the vast array of information into guidelines that are usable as aids for the software designer or evaluator. designers (Smith and Mosier, 1984; Stoddard, 1985). Although compilation of USI design information into guidelines seems inherently attractive, USI guidelines have been met with mixed reactions. The usefulness of USI design guidelines as a de-

sign tool has recently been challenged (Mosier and Smith, 1985).

Criticisms against existing guidelines are that they are often too general to be useful to the average software designer or evaluator, or they can only be used by USI design experts. Critics point out that few guidelines can be used in their existing forms. They are much too general and abstract in nature, leaving too much to the user's interpretation (Granda, 1980; Smith and Mosier, 1984). Conversely, it has been suggested that USI design is a very application-dependent process, whereas guidelines are written for the broad range of interactive systems. Instead of guidelines, it is suggested that general USI principles and proceduralized design principles are potentially more useful for software design and evaluation (Ramsey and Atwood, 1980).

Although research with online HELP systems indicates that hardcopy reference materials may be easier to use than online references, this may be an application specific phenomenon (Cohill and Williges, 1982). Accessing HELP information makes greater usage of short-term memory and often does not require the higher order, problem solving, cognitive processes associated with software design (Price, 1982). A computer's capability for rapid search and access of specific data can possibly facilitate the use of an online technical

reference over a hardcopy manual. This becomes especially important with the kinds of cross-indexed information that is found in most database systems, a type of software system to which the online reference is closely related. Furthermore, in subjective evaluations, people rated online manuals as better and more organized than paper manuals (Weldon, Mills, Koved and Schneiderman, 1985).

This thesis examines the effects of the the level of abstraction of guidelines and their presentation medium on software engineers' evaluations of USI prototypes. Included is an assessment of the ability of software engineers to use guidelines that have differing levels of abstraction. The guidelines used in the study were drawn from the Design Guidelines for User-System Interface (Smith and Mosier, 1984).

METHOD

OPERATIONAL DEFINITIONS OF GUIDELINE CATEGORIES

Operational Definitions

User interface guidelines form a continuum with concrete and abstract as end points. Concrete guidelines are specific and are not open to interpretation. They make statements that can be directly used in most applications. Some guidelines are quantitative; however, many are not. For instance, one concrete but non-quantitative guideline states that "In multi-paged displays, label each page to show its relation to the others."

Abstract guidelines have a level of generality that requires them to be translated into forms the designer can use. These guidelines are generally qualitative and require the designer to make assumptions about the end-users or the boundaries of the interface. One such example is the guideline that states "Consider blink coding for applications where a displayed item implies an urgent need for user attention." It is left to the designer to define what is meant by an "urgent need."

Testing of the Operational Definitions

The researcher compiled two lists of guidelines from sections 1-4 of the Smith and Mosier (1984) guidelines so as to form sample sets of concrete and abstract guidelines. The guidelines deal with data entry, data display, sequence control, and user guidance. The researcher identified 50 concrete and 55 abstract guidelines. To validate that these guidelines consensually fall within one or the other extremes of the guideline specificity continuum, two human factors graduate students in the Department of Industrial Engineering and Operations Research at Virginia Polytechnic Institute and State University (VPI&SU) were asked to sort a shuffled deck of index cards containing the 105 guidelines into these two categories. Conflicts in categorization of the guidelines between the two students and the researcher were identified and the discrepant guidelines were eliminated. The remaining 46 concrete and 41 abstract guidelines were reduced to lists of 22 guidelines. The reduction was made based upon the ease of implementation within the USI prototypes. One final guideline was dropped from consideration from each set during the pilot study due to a problem in implementation. The resulting sets of 21 concrete and abstract guidelines are presented in Appendices A-3 and A-4, respectively.

EXPERIMENTAL DESIGN

The research consisted of the 2x2x2 mixed-factors design shown in Figure 4. The experiment addressed the effects of presenting USI guidelines in an online form versus hardcopy form on designers' evaluations of two alternative prototyped interfaces. The subjects, who consisted of programmers/designers, were randomly assigned to the groups to control for subject variability.

The within-subject factor in the experimental design was the types of guidelines, concrete or abstract, which the prototypes violate. Two different prototypes of a command driven system were used. They differed in that one prototype violated abstract guidelines and the other violated concrete guidelines. Any ordering effect that resulted from the sequence in which the two prototypes were viewed was controlled for by treating viewing sequence as another between-subjects variable.

DEPENDENT MEASURES

The experiment compared the subjects' evaluations of the interfaces prototyped by the researcher. Subjective data concerning the utility of the guideline were collected with a questionnaire administered after the test sessions. A de-

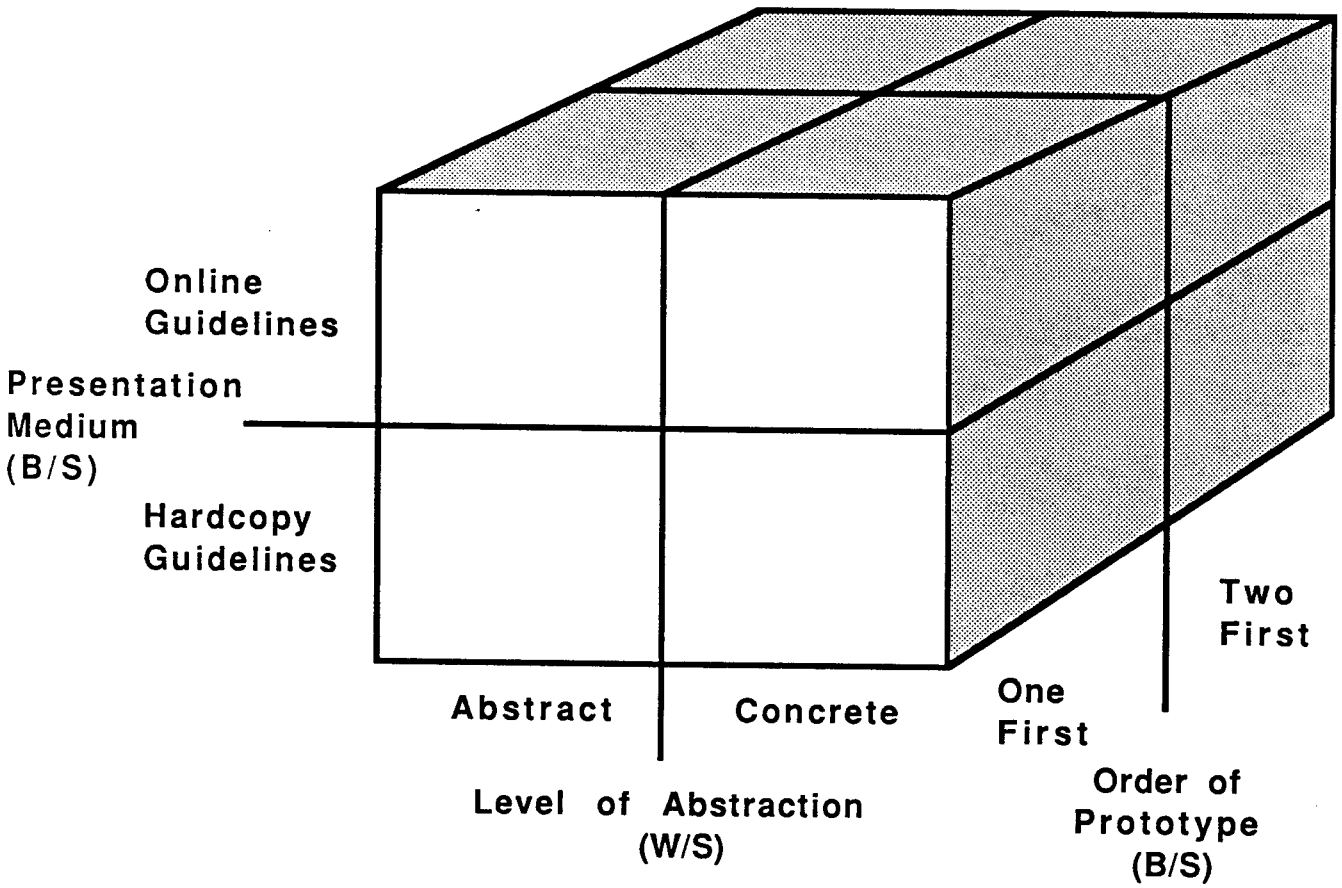


Figure 4. Diagram of the 2x2x2 mixed factor experimental design

pendent measure taken from the experiment was the amount of time spent for each evaluation. Also, the times spent using the table of contents and index were collected. The researcher used a digital clock appearing on the video recording of each session to collect these temporal data.

Another measure taken from the evaluation trials was the number of embedded guideline violations detected for each prototype. For each of these detected violations, the subject's confidence of the violation and the assessment of criticality of the violation were gathered using a 5-point subjective evaluation scale.

SUBJECTS

Eight subjects were randomly assigned to each of the two guideline presentation groups. The subjects within each of these guideline presentation groups were also randomly assigned to one of two subgroups differing in the order that they ran the prototypes to be evaluated. The subjects were senior level computer science majors from VPI&SU's computer science program. These subjects had less than three man months or one school quarter of experience in designing a USI. They were assumed to be representative of the population of entry-level software designers about to begin their computer and USI systems development careers. All subjects

were paid $5.00 an hour (for an expected six hours each) and were required to sign an informed-consent form.

HARDWARE

Computer Hardware

The computer system used was the VAX station II produced by Digital Equipment Corporation (DEC). The prototyped USIs ran on the VAX station II. All subjects used and interacted with the prototypes during the evaluation process. The online browsing library containing the Smith and Mosier guidelines (1984) used by one of the experimental group was also hosted on the VAX station. The multi-windowing capability of the VAX workstation allowed both the prototype being evaluated and the online system to be displayed at the same time. The subject switched from the prototype and the online system by using a mouse.

Additional Hardware/Materials

A hardcopy manual containing a subset of the 679 USI guidelines found in the Design Guidelines for User-System Interface Software (Smith and Mosier, 1984) was used by one of the evaluation aid groups. The set of guidelines was modified to match the knowledge base found in the online browsing li-

brary. Some guidelines that seem to be rephrasings of the violated guidelines were deleted from the set. The subset was limited to sections 1-4 of the guidelines. These sections are data entry, data display, sequence control, and user guidance. Page numbers, coded by sections, were placed on the pages of the manual. The manual itself was placed in an upright position on a secretarial paper stand so that the experimenter could see, through the use of a visual monitoring system, the section of the manual that the subject was looking at at any given time.

A video camera was used to monitor the subject as he or she interacted with the prototypes and technical librarian (TL) on the VAX station II. A second video camera was used to observe the sections of the guidelines that subjects in the hard-copy experimental group looked at as they evaluated the prototypes. The video camera was positioned so that the experimenter could see the large numbers on the pages of the manual. For the TL group, the second camera covered the TL window so that the title of the page could be recorded. The video system had a clocking capability to collect temporal data. The video cameras were connected to a video special effects generator and mixer which in turn was connected to a VHS recorder and a real time monitor. A clip-on microphone and an audio mixer were also used and connected to the VHS recorder to collect verbal protocol data.

SOFTWARE

RIPL's Technical Librarian

The technical librarian (TL) is one of three subsystems of the Rapid Intelligent Prototyping Laboratory (RIPL) developed by Computer Technology Associates (CTA) (Lenorovitz and Reaux, 1986). The underlying concept of the TL is that of an electronic textbook containing the Smith and Mosier guidelines (1984). It is an online book management software system that enables the user to access indexed information directly by using the subject- matter indexing mode or major contents headings by using the table of contents mode. It also allows the user to browse through the content of the book. The software is written in Pascal and runs in a VAX workstation environment.

USI Prototypes

Two USI prototypes were developed by the researcher. They were written in VAX Pascal using VAX's Screen Management procedures and ran on the VAX station II. Embedded in these prototypes were violations of certain Smith and Mosier Guidelines. Prototype 1 violated the 21 concrete guidelines in Appendix A. Prototype 2 violated the 21 abstract guide-

lines that are also shown in Appendix A. A snapshot from the prototyped USIs is shown in Figure 5.

Both prototypes were intended to represdent the front end of a data base management system (DBMS). Each prototype was a variation of a command-driven system. These prototypes were interactive, allowing the subjects to enter certain commands as dictated by task instruction sets that they were provided (see Appendix C). The hypothetical DBMS was a customer accounts management system that used by a bank. The target users were account managers who had little or no programming experience.

Two other prototypes were also built by the experimenter and used in the practice sessions intended to familiarize the subjects with the evaluation task. The first prototype consisted of a static display presented to the subject. The display was a noninteractive representation of a page from an online reference manual. The second prototype supported limited interactions and depicted an employee address database (see Appendix C). Each practice prototype had three guideline violations embedded in it. Care was taken to make these violations distinctive from those in the two prototypes used in the evaluation trials.

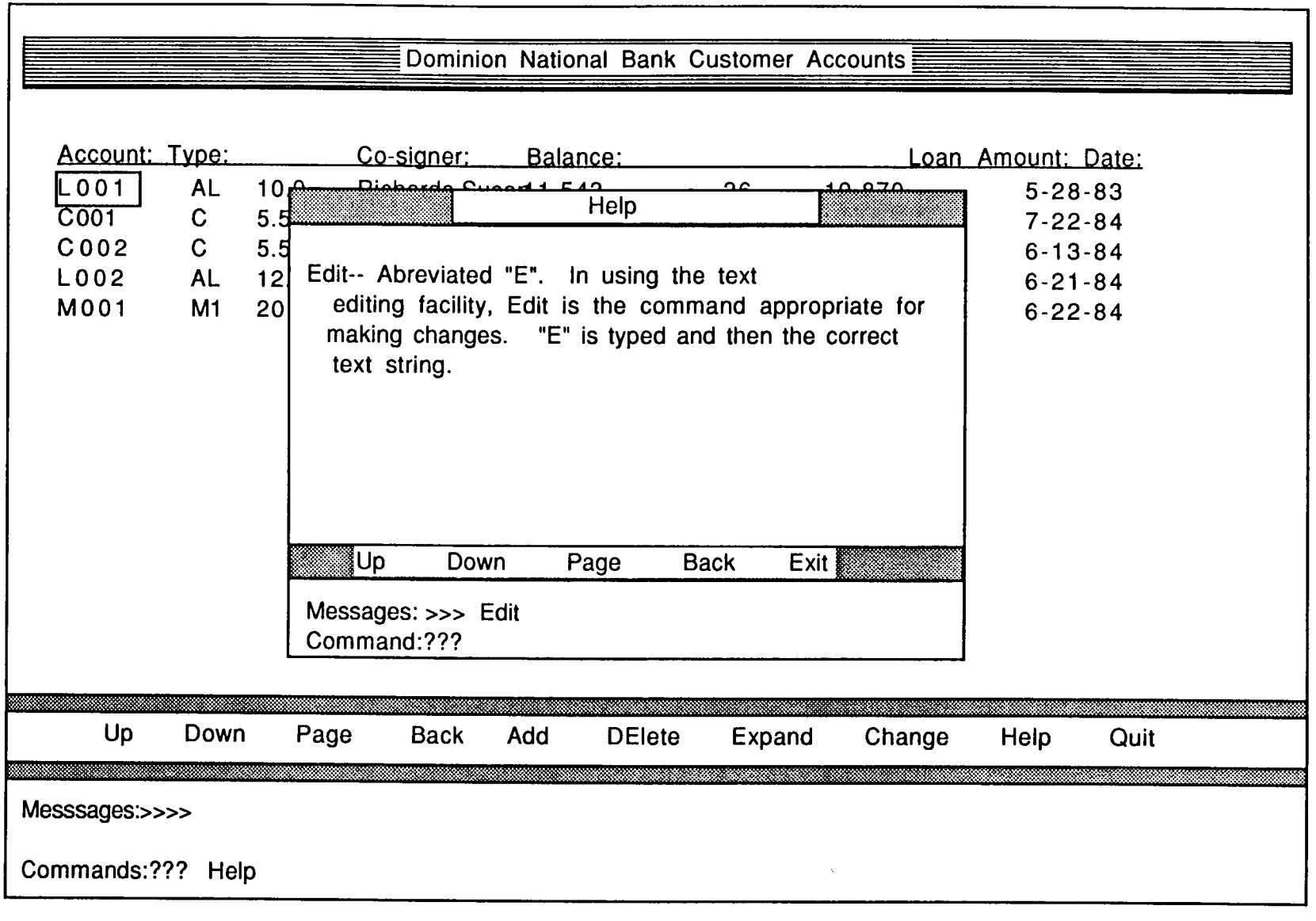


Figure 5. Snapshot of a prototyped interface with embedded USI violations

USI PROTOTYPE EVALUATION PROCEDURE

The evaluation procedures were separated into three sessions. The first session was a training session that took approximately an hour to an hour and a half. The other two sessions had no time constraints although no subject took more than three hours. All sessions were separated by at least two hours and, no more than two sessions occurred during a 24 hour period.

During the training session, as shown in Figure 6, subjects were asked to sign an informed-consent form that explained their rights as subjects. They were then expected to complete Questionnaire 1 (see Appendix D) which asked questions concerning their education and experience using computers and in USI design. The subjects listened to a ten minute audio tape explaining the organization of the Smith and Mosier guidelines (1984). They were also provided with the script to follow along with the tape. The subjects were given 20 minutes to browse through the hardcopy version of the guidelines and thus become familiar with the guidelines structure and content. The subjects using the TL also viewed a 15 minute training videotape that explained how to use the various commands of the TL. These subjects were then given five minutes to practice with the TL. Similarly, the subjects using the hardcopy manual of guidelines were asked to spend

five minutes practicing lookups of various topic areas and guidelines using the table of contents and the index of the manual.

After the five minutes, all subjects were given a five question quiz that tested their ability to use the manual or online system in look ups. If subjects did not meet a criterion score of four out of five correct responses on the quiz, they were retrained, either by having them read the script for the TL training tape or again browse through the hardcopy manual for ten minutes. Only three subjects required retraining. These subjects were then given a second quiz of four questions. They were expected to respond correctly to all four questions. Those that could not would have been excluded from the experiment. No subjects failed to meet this second criterion. The text for the introduction to the USI guidelines and the TL are given in Appendix B. The criterion quizzes are shown in Appendix D.

The subjects were instructed to record the USI design guidelines violations that they found on a form provided for them (see Appendix D). They were also told to verbalize as they performed the evaluation task, explaining what they were looking at and what they thought was wrong with the interface. For each violation detected, they were asked to try to find and record a reference number for the guideline from

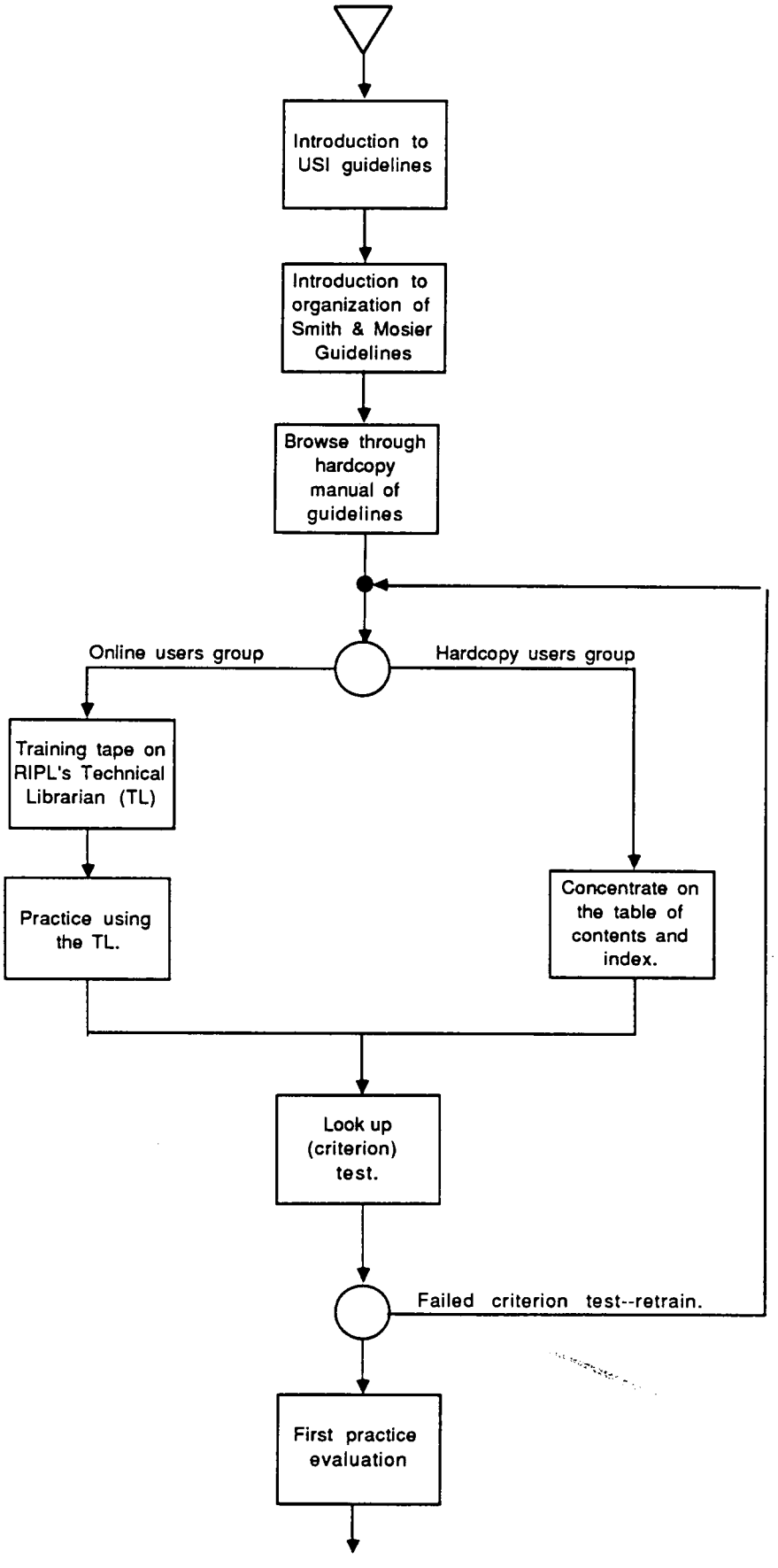


Figure 6. Diagram of the training procedure -- Session 1

the manual or TL. The subjects were told that if they were unable to locate a guideline reference numberthey should proceed with the evaluation. The subjects were also asked to rate each USI violation that they located along two five-point dimensions. These dimensions included how confident they were that what they found was indeed a violation, and how critical they thought the violation was to the USI. It was stressed to the user that the guidelines set was to be used not only to justify the USI violations that they found but also as a design evaluation tool to find problems in the USI that they would normally overlook if relying on their own experience and knowledge. In that regard, subjects responded after using the guidelines that they did use it as an evaluation tool. These instructions were given prior to each practice trial as well as during the actual evaluation sessions.

The subjects practiced evaluating an interface for 15 minutes. The interface that they evaluated, using their respective guidelines medium, consisted of the static view of the reference manual. Embedded within this prototype were three USI guidelines violations. Following the 15-minute evaluation, the subjects were shown the three sample violations and their respective guidelines (shown in Appendix A) in the knowledge base. During the second session, before the subjects began the first test trial, they had a second

15 minute practice trial. This practice trial used the interactive account data base prototype. After the practice period, the subject had an option to take a five minute break before proceeding to the first evaluation trial.

During the second and third sessions, the subjects ran one of two prototypes built by the researcher. The testing procedure is depicted graphically in Figure 7. The prototypes were divided into five sections. The subjects were guided through each section in a step by step, user driven procedure, so that all subjects had a chance to see certain features of the interface. After running each section, the subjects were asked to identify from 0 to 10 USI guidelines that were violated in the section and to indicate on a scale of 1 to 5 how confident they were that the guideline identified was violated and how critical the violation was to the usability of the USI.

Subjects were expected to use the design aids (online guidelines or hardcopy of the guidelines) with which they were provided. These two evaluation trials had no time constraints. The subjects could take as much time as they required. The task instructions for the two prototypes as well as for the two practice trials are presented in Appendix B. During each test the researcher monitored the subject at an experimenter's workstation in an adjoining room.

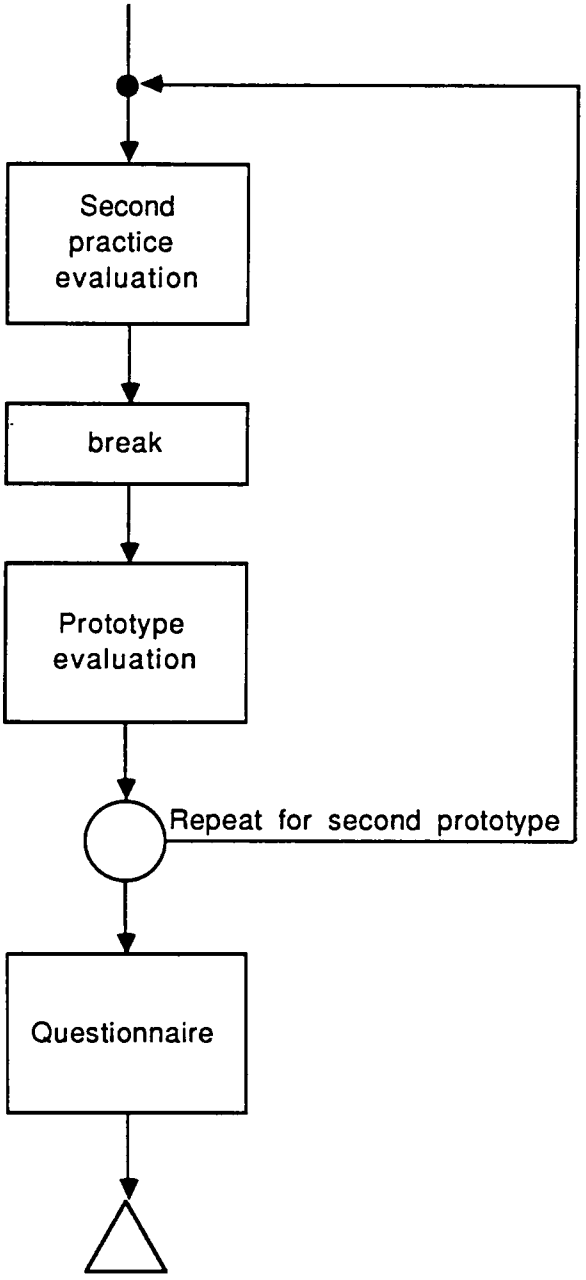


Figure 7. Diagram of the testing procedure - Sessions 1 and 2.

Following the tests, those subjects that were provided guidelines were asked to complete Questionnaire 2 (see Appendix C) concerning guideline usability. All subjects were reimbursed for their time.

RESULTS AND DISCUSSION

GUIDELINES VIOLATIONS FOUND

Tables 3 and 4 lists the frequencies of detection for the concrete guideline violations embedded in Prototype 1 and abstract guideline violations embedded in Prototype 2, respectively. The number of guidelines found by the subjects for each test prototype was analyzed using a mixed factor analysis of variance (ANOVA) design. The table for this ANOVA is shown in Table 5. The analysis indicated that the main effect of level of abstraction of guidelines is significant. $p < 0.0001$, with $F = 40.49$. The subjects found almost twice as many concrete guidelines violations embedded in Prototype 1 than they did abstract guidelines violations embedded in Prototype 2. The means for concrete and abstract violations found by the subjects were 10.50 and 5.94, respectively. The ranges were between six and fourteen detections for concrete guidelines violations, and three and eight for the abstract guideline violations.

As was predicted, the subjects found more violations of concrete guidelines than abstract guidelines. Recognizing violations of abstract guidelines is a more complex task than recognizing violations of concrete guidelines. The evalu-

Table 3. Detection frequencies for concrete guideline violations

Guideline Title	Guideline Chapter	Frequency
Data field labeling	data display	15
Justification of numeric data	data display	14
Justification of alphabetic data	data display	14
Reviewing destructive commands	sequence control	14
Numbered items start with "1"	data display	11
Upper/lower case equivalent	data entry	10
Display of default values	data entry	9
List ordering multiple columns	data display	9
Labeling units of measurement	data display	9
Display title at top	data display	9
Consistent column spacing	data display	7
Page labeling	data display	7
Standard area for code entry	sequence control	7
Consistent coding of menu options	sequence control	7
Consistent word spacing	data display	6
Feedback for control entries	sequence control	5
Blinking marker symbols	data display	4
Consistent display of menu options	sequence control	4
Active voice	data display	3
Letter codes for menu selection	sequence control	2
Command entry, prompts, messages at bottom	data display	2

ation of the violations of abstract guidelines in Prototype 2 is a two-step process of setting criteria and then checking the USI elements against them. Finding violations of concrete guidelines in Prototype 1 is a simpler process which does not require the guideline user to interpret the criteria from the guidelines. An example of a guideline that states a criterion is "blinking cursors should have a cycle of 2-5 Hz." A violated guideline in Prototype 2 states that error

Table 4. Detection frequencies for abstract guideline violations

Guideline Title	Guideline Chapter	Frequency
Brief error messages	user guidance	11
Logical organization	data display	10
Informative labels	data display	10
Easy way to get guidance	user guidance	9
Only necessary data displayed	data display	8
Familiar units of measurement	data entry	7
Familiar wording	data display	7
Necessary data displayed	data display	6
Distinctive label format	data entry	5
Visually distinctive data fields	data display	5
Labels close to data fields	data display	3
Data grouped by importance	data display	3
Distinctive display of control information	data display	3
Distinctive wording of	sequence control	2
Distinctive wording of labels	data display	2
Minimal hyphenations	data display	2
Highlighting critical data	data display	1
Simple sentence structure commands	data display	1
Clarity of wording	data display	0
Meaningful codes	data display	0
Meaningful display labels	data display	0

messages should be brief and informative. The guideline user must first decide what error message lengths are unacceptable. He must also decide how much information an error message should carry, perhaps as a function of message length.

For USI experts, the variance in criterion interpretations of one person compared to another may not be large. However,

Table 5. ANOVA table for embedded USI violations found.

Source	df	MS	F	P
Between Subjects				
Guideline Media (M)	1	0.5000	0.10	0.7601
Order (O)	1	4.5000	0.88	0.3672
MxO	1	0.0000	0.00	1.0000
S/MO	12	61.5000		
Within Subject				
Abstraction (G)*	1	180.5000	40.49	0.0001
AxM	1	0.5000	0.11	0.7435
AxM	1	0.0000	0.00	1.0000
AxMxO	1	0.5000	0.11	0.7435
AxS/MO	12	53.5000		
Total	31	301.5000		

* significant at $p < 0.0001$

since the average beginning software engineer often has little USI background upon which to base his interpretations, much greater variance can be expected. The evaluator must rely on prior experience and expectations; thus, criterion establishment is more a function of personal preferences and subjective "feelings" rather than a shared body of knowledge.

PROTOTYPE EVALUATION AND GUIDELINE USAGE TIME

Time data collected in the experiment were analyzed using a mixed factor ANOVA. The results of the ANOVA for all the time data are presented together in this section since the data provided insight into search strategies of guideline users.

The ANOVA test results for the ratio of time spent using the Smith and Mosier guideline sets to total prototype evaluation time are shown in Table 6. The analysis indicated that the main effect of guidelines presentation medium is significant, $p < 0.0007$, with $F = 20.30$. Subjects using the TL had a guidelines usage to evaluation time ratio of 0.5638. Subjects using the hardcopy guidelines set had a guidelines usage to total evaluation time ratio of 0.4424. The subjects spent the rest of the time interacting with the interface, examining the interface or recording the violations.

The ANOVA summary table, shown as Table 7, for the ratio of time spent using the table of contents and the index to total guidelines set usage time indicates that the main effect of guidelines presentation medium is significant, $p < 0.0015$, with $F = 16.61$. The TL subjects had a mean ratio of time using the table of contents and the index to time using the guidelines of 0.3157. The hardcopy subjects had a mean ratio of 0.1984.

Table 6. ANOVA table for guidelines usage time.

Source	df	MS	F	P
Between Subjects				
Guideline Media (M)*	1	0.1778	20.30	0.0007
Order (O)	1	0.0026	0.30	0.5932
MxO	1	0.0004	0.05	0.8319
S/MO	12	0.1051		
Within Subject				
Abstraction (A)	1	0.0001	0.05	0.8212
AxM	1	0.0001	0.05	0.8217
AxO	1	0.0138	0.87	0.3689
AxMxO	1	0.0000	0.12	0.8958
AxS/MO	12	0.0189		
Total	31	0.306		

* significant at $p < 0.0007$

The ANOVA summary table for the ratio of time spent using the table of contents to total guidelines set usage time is shown in Table 8. The analysis indicated that the main effect of guidelines presentation medium is significant, $p < 0.0039$, with $F = 12.73$. The TL subjects had a mean ratio of time using the table of contents to time using the guidelines of

Table 7. ANOVA table for table of contents and index usage.

Source	df	MS	F	P
Between Subjects				
Guideline Media (M)*	1	0.1228	16.61	0.0015
Order (O)	1	0.0256	3.46	0.0875
MxO	1	0.0004	0.05	0.8210
S/MO	12	0.0887		
Within Subject				
Abstraction (A)	1	0.0013	0.47	0.5069
AxM	1	0.0008	0.29	0.6030
AxO	1	0.0003	0.11	0.7432
AxMxO	1	0.0115	4.07	0.0665
AxS/MO	12	0.0338		
Total	31	0.2857		

* significant at $p < 0.0015$

0.0851. The hardcopy subjects had an even smaller ratio of 0.0429. Although the subjects using the TL used the table of contents in all evaluation trials, the subjects using the hardcopy guidelines set did not use the table of contents in over half the trials.

Table 8. ANOVA table for the ratio of table of contents usage.

Source	df	MS	F	P
Between Subjects				
Guideline Media (M)*	1	0.0472	12.73	0.0039
Order (O)	1	0.0031	0.84	0.3778
MxO	1	0.0000	0.00	0.9805
S/MO	12	0.0445		
Within Subject				
Abstraction (A)	1	0.0001	0.10	0.7569
AxM	1	0.0002	0.12	0.7328
AxO	1	0.0014	1.04	0.3269
AxMxO	1	0.0001	0.09	0.7738
AxS/MO	12	0.0161		
Total	31	0.1127		

* significant at $p < 0.0039$

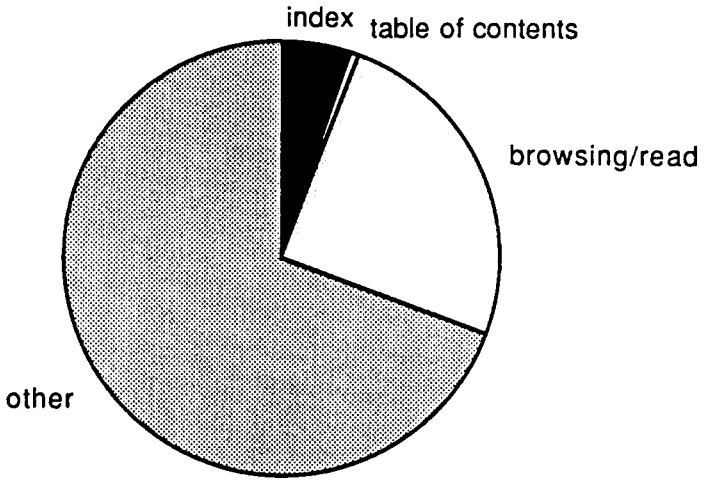
ANOVA tests were also conducted for the data collected for the total evaluation time and for the ratio of time spent using the index to using the guidelines set. These data showed no significant differences ($p > 0.05$) level. The ANOVA summary tables for these tests are shown in Appendix E. The hardcopy medium group had means of 4447 s and 0.0110

for the total time spent in the evaluation and the ratio of index usage time to the guidelines usage time, respectively. The online group had means of 5444 s and 0.0140. The pie charts shown in Figure 8 show the breakdown of time spent by subjects, as a function of guideline presentation medium, in the evaluation process.

Pearson tests for correlation were run between the number of guideline violations detected and the total time spent in the evaluation as well as the time spent using the guideline set. Level of guidelines abstraction and guideline presentation media were used as factors. No significance was found. The test results are shown in Appendix E.

The means for the ratio of guidelines set usage time to evaluation time is significantly higher for the group using the online system than for the group using the hardcopy manual. However, they found the same number of guideline violations as subjects using the hardcopy set. This difference arises from the different search strategies the two guideline presentation media impose on the user. Further evidence for this explanation comes from the significant differences in the search time using the table of contents and index. The subjects using the hardcopy manual took less time in using the index and the table of contents than subjects using the

Breakdown of time spent by subjects using hardcopy manual in the evaluation tasks



Breakdown of time spent by subjects using the online manual in the evaluation task

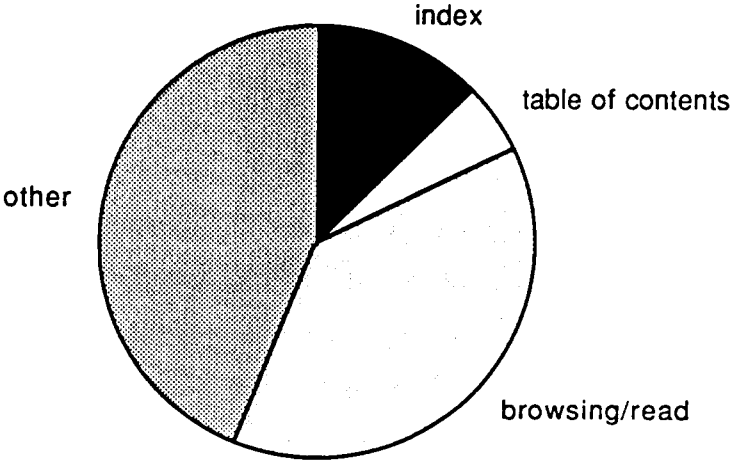


Figure 8. Pie charts of the time subjects spent in evaluation as a function of guideline presentation media.

TL. In fact, over half of the subjects using the hardcopy manual did not use the table of contents.

SUBJECTS' CONFIDENCE AND CRITICALITY FOR FOUND VIOLATIONS

Since the subjective ratings of confidence and criticality are at best ordinal scale data, the Kruskal-Wallis test was used to test for significant differences in ratings as a factor of prototype evaluated and as a factor of the guideline presentation medium. The results of the test are given in Table 9. The test shows significance (Chi-square $p < 0.0001$) only for confidence rating as a function of the prototype evaluated. This rating difference can be seen graphically in Figure 9. which shows the frequency ratio distributions for each of the five possible responses. The frequency ratio responses for criticality as a function of prototype and for both confidence and criticality as a function of presentation media are shown in Appendix E.

It is not surprising that the subjects rated higher confidence in the embedded guideline violations that they found in Prototype 1 than those they found in Prototype 2 since Prototype 1 violates concrete guidelines (requiring little or no user interpretation) and Prototype 2 violates abstract guidelines (requiring user interpretation) the difference is understandable. The increased level of abstraction, which

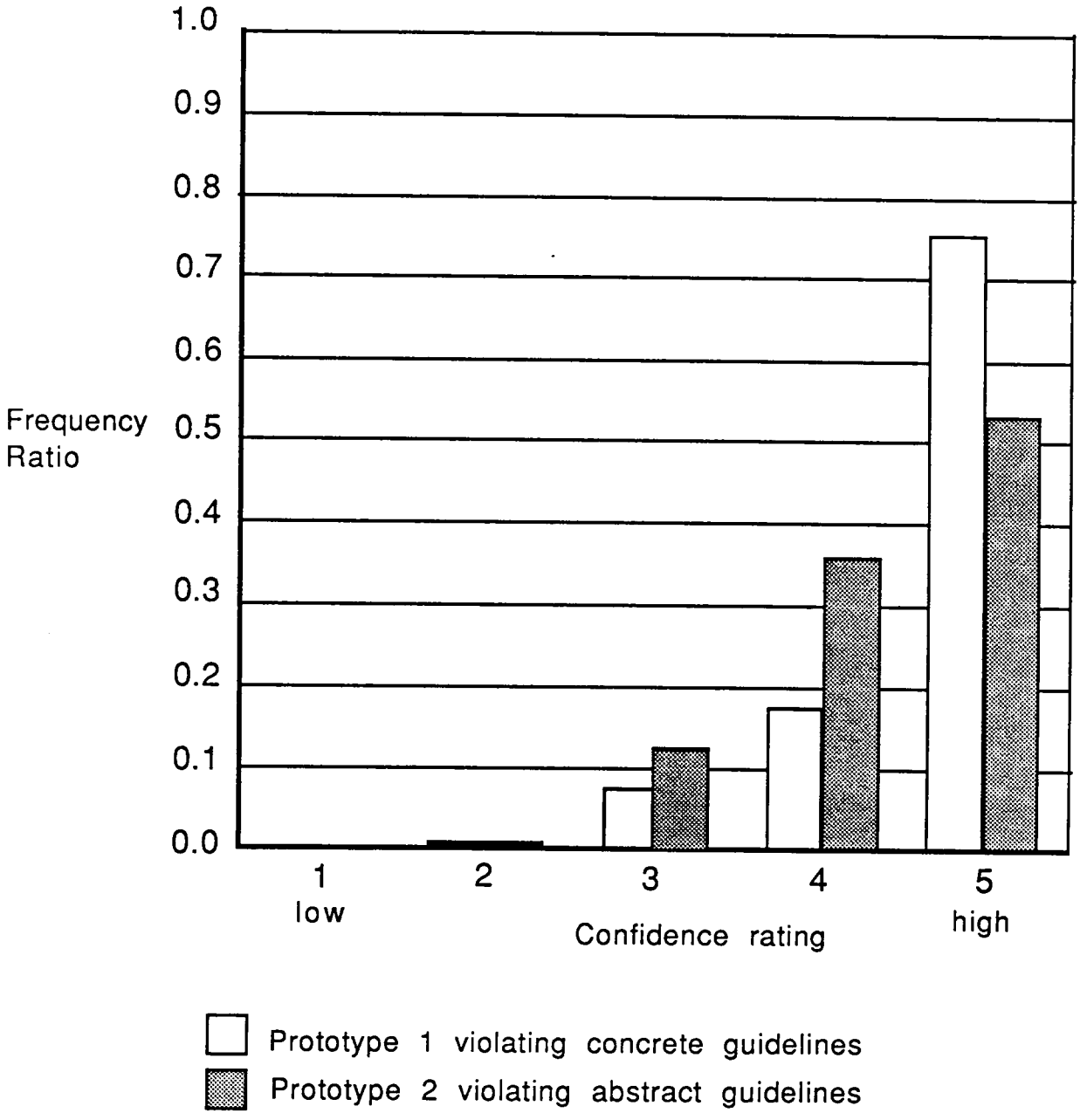


Figure 9 Ratio distributions of confidence for embedded violations found.

Table 9. Test for confidence and criticality for found violations.

(Kruskal-Wallis test of Chi-square approximation)

Source	df	Chi-square value	p
Confidence by prototype*	1	18.32	0.0001
Criticality by prototype	1	2.65	0.1033
Confidence by medium	1	1.26	0.2620
Criticality by medium	1	0.22	0.6367

* Significant at $p < 0.0001$

requires user interpretation, introduces uncertainty into the guidelines usage task. Since no firm criterion is given upon which the subject can base his evaluation of an interface element, the subject must rely on his subjective understanding of what is acceptable or not acceptable. Thus, a subject may not "know" but only "believe" that a violation exists.

SUBJECTS' RESPONSES TO QUESTIONNAIRE 2

In evaluating the responses to questions 1 through 16 of Questionnaire 2 (see Appendix D-6) dealing with guidelines usability, only question 10 yielded a significant difference between the subjects using the hardcopy guidelines medium and the online TL (Kruskal-Wallis test shows significant differ-

ences (Chi-square $p < 0.0421$). Question 10 asks whether there should be more examples in the guidelines set. Table 10 gives the results of the Kruskal-Wallis test for the questions in Questionnaire 2. As can be seen in Figure 10, more subjects using hardcopy guidelines agreed that the guidelines should contain more examples than those subjects using the TL. The frequency ratio ditributions of responses for the other questions of Questionnaire 2 are presented in Appendix E.

The reason for the difference in response between the two groups for question 10 is not readily apparent. However, since the TL is an online system, it may well serve as a continuous example for the guidelines user. If so, the on-line system may subtly bias the user's evaluation of the interface, causing the evaluator to use the online system as the "standard" to which the interface being evaluated is compared. If such a biasing effect exists, it does not seem to have been strong enough to cause any significant differences in the number of embedded guideline violations found in the prototypes between the two guideline presentation groups ($p = 0.7601$).

The subjects generally agreed that the guidelines are an important tool for USI design and that they would like to use the guidelines in USI design and evaluation. They thought

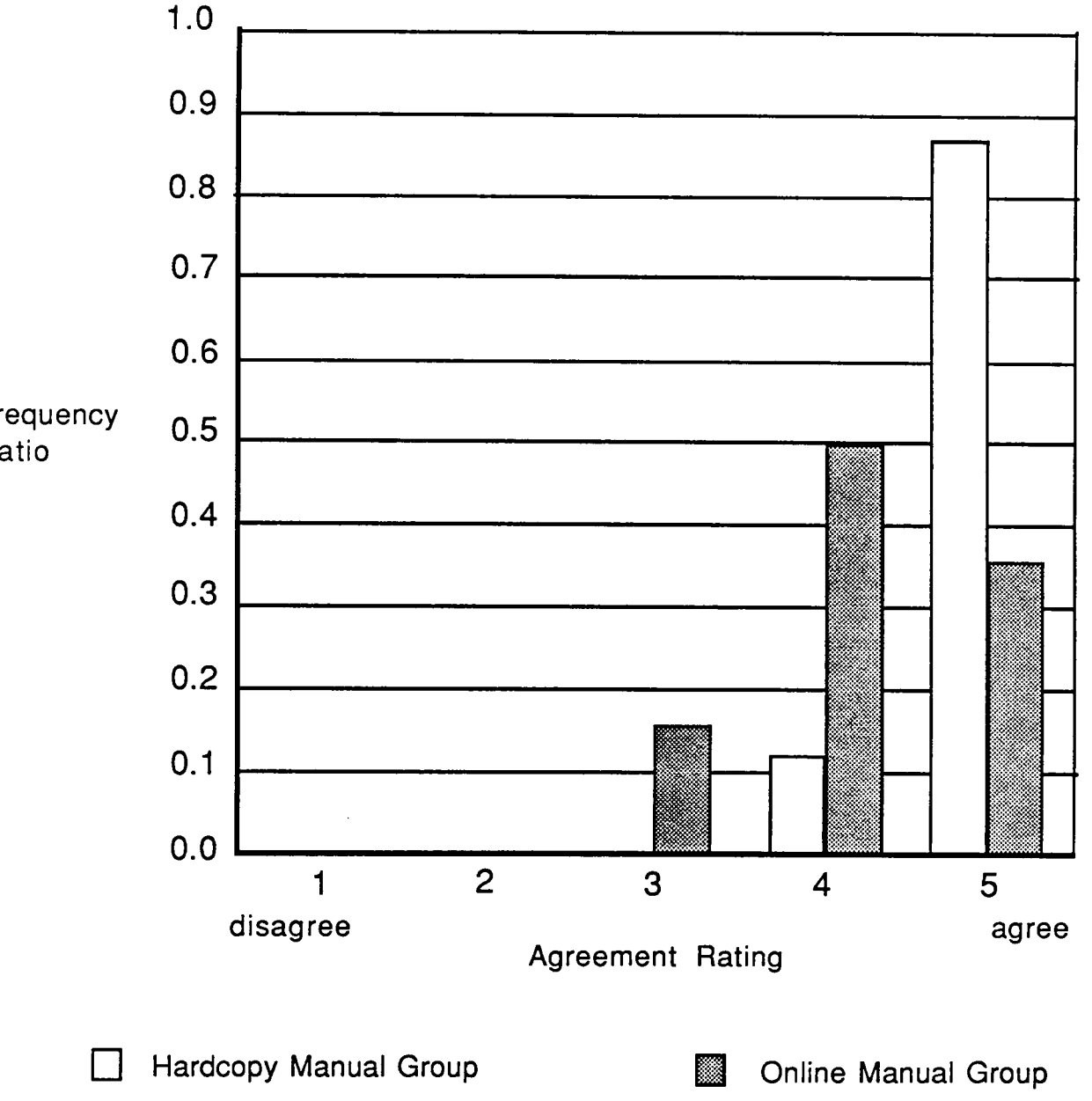


Figure 10. Ratio distributions of responses to question 10 (Should more examples be given in the guidelines)

Table 10. Test of responses to Questionnaire 2.

Presentation media of the Guidelines is used as the independent variable. (Kruskal-Wallis test of Chi-square approximation.)

Source	df	Chi-square value	p
Question 1	1	1.30	0.2496
Question 2	1	0.15	0.7025
Question 3	1	0.00	0.9539
Question 4	1	0.01	0.9273
Question 5	1	1.25	0.2627
Question 6	1	0.12	0.7319
Question 7	1	1.44	0.2301
Question 8	1	1.68	0.1949
Question 9	1	0.34	0.5579
Question 10*	1	4.12	0.0423
Question 11	1	2.50	0.1138
Question 12	1	1.84	0.1752
Question 13	1	2.51	0.1128
Question 14	1	1.40	0.2363
Question 15	1	0.01	0.9121
Question 16	1	1.37	0.2425

* Significant at $p < 0.043$

that they would not need the help of a human factors expert to use the guidelines; however, they did not agree on whether the guidelines were cumbersome and complex or their confidence in using the guidelines. The results were not conclusive about whether people could learn to use the guidelines quickly. The subjects did agree that examples were helpful in understanding the guidelines and that more examples should

be included. Most disagreed that the guidelines needed to be more quantitative. The subjects did not agree on whether they would like to have the guidelines set in an online system rather than as a hardcopy manual.

CONCLUSION

USER'S SEARCH STRATEGY

In the study, the subjects took less time using the hardcopy manual than the online system. For novices to USI design issues, the hardcopy manual is definitely easier to use. The book medium is one familiar to them. The hardcopy manual supports browsing far better than the online system since it provides spatial cues, a greater view window, and context information. The online system loses much of this information.

The hardcopy manual group has several advantages over the online system group. The physical structure of the hardcopy manual allows the use of spatial cues in searching for chapters, sections, and subsection. Tests of individual differences in searching a hierarchial file system indicate that vocabulary and spatial visualization were the best predictors of performance on the hierarchical information retrieval system. And of these, spatial visualization was the stronger predictor (Vicente, 1987). The spatial relations can be retained in memory by the user so that he or she can use the cues to return to that guideline section at a later time. Since the subjects used the hardcopy manual as a training

tool to become familiar with the guidelines, the subjects may well have identified and retained these spatial cues during the training session. The subjects using the TL have no analogous physical structure to provide spatial cues for finding chapters, sections and subsections. For them, the physical arrangement of the guidelines is totally transparent.

With high resolution graphics offered by state of the art workstations, the two dimensional nature of the online system may be compensated for, if not completely overcome. The analog information can be simulated by introducing the three dimensional appearance of a book. A pointer can play the role of a finger for thumbing through the manual, with the beginning pages of major section headings having "tabs." Even if the workstation cannot support complex graphics, analog displays such as relational scroll bars with marked sections can provide visual cues that present systems such as RIPL's Technical Librarian lack.

The subjects using the TL spent more time using the index than the subjects using the hardcopy manual. Since the online system is limited to a maximum of 19 lines, it suffers from a more limited view window than the hardcopy manual which contains more than 30 lines per page. The hierarchical organization of the table of contents and the index is also

enforced by having collapsible sections and subsections. This limits transfer of context information. But the large view window that a book offers can be duplicated in the modern workstation. Workstations such as the ones resident on the MicroVAX II have large monitors that can open windows with numbers of lines comparable to a book.

Finally, research has indicated that reading from a CRT can be significantly slower than from paper. Although reading speed for CRTs can be optomized to that for paper by careful control of variables such as fonts, contrast, resolution, and polarity, no such optomization was made for this experiment (Gould, et al., 1987).

GUIDING THE USI GUIDELINES USER

The online system supports search utilities such as the Locate command. However, any string search command assumes that the subjects know keywords. This is too much to ask of people who are unfamiliar with USI terminology. People who are not USI experts do not necessarily possess a sufficient dictionary of USI keywords upon which to base string searches.

However, online systems offer the potential to guide users. For novice USI designers, this is especially important since

they lack expertise in USI design. The system can make up for some of this ignorance. The set of guidelines is large and can be intimidating. An expert system built over the browsing system can reduce, based on design constraints, applications, and other high level parameters, the set of guidelines to easier manageable subsets relevant to the user's design application problem. This differs from the expert system that RIPL supports. RIPL's expert system, makes recommendations on what types of interface are best suited, given a set of parameters, for a system. It supports high level decisions concerning the USI such as whether to use menus or a command driven interface. The recommendations made are based on assumptions about the interface and requires a complex and extensive set of production rules.

Reduction of the guidelines set does not make assumptions as much as remove irrelevant material, thereby reducing the number of guidelines that the user has to look at and consider. This is especially useful for evaluating a USI using a checklist methodology. A complex knowledge base of production rules is not needed. What is needed, however, is a dictionary (something that novice designers lack) of keywords that the reduction can be based on. The system then is more like a relational database with macro searches than a traditional expert system.

The two online and hardcopy media should complement each other. The hardcopy format seems more appropriate for the USI novice. However, once the user has developed an understanding of USI issues and a working vocabulary of USI keywords, the online system may become more useful. To support the full range of users, USI design aid systems, such as RIPL should provide both information media, an online browsing system, as well as a hardcopy manual containing the same material.

DYNAMIC EXAMPLES

As the research indicated, there was a significant difference in response between the online systems user and the hardcopy manual user concerning the need for more examples. The hardcopy group expressed a greater need for more examples than did the online group. As was previously mentioned, this difference may be attributable to the online guidelines users using the online system itself as an example. If so, it may be beneficial to provide guideline users with dynamic examples of different interfaces, since such biasing of the user by the online system's interface can limit the range of USIs that the user will consider. Dynamic examples of interfaces, or pregenerated prototypes, would offer the communicative advantage of greater face validity than do static examples.

LEVEL OF ABSTRACTION OF GUIDELINES

The level of abstraction of a guideline definitely affects the usability of the guideline. Subjects consistently applied concrete guidelines more readily than abstract guidelines in evaluating USI problems. Two conclusions can be stated from this result. First, a need exists for a cognitive model of the USI evaluation task, from which a general procedure outlining the evaluation task can be derived. It is apparent that identifying violations of concrete guidelines is a simpler task than identifying violations of abstract guidelines. Abstract guidelines require the user to establish the criteria against which the USI elements are compared. The concrete guidelines do not force this step upon the user, since the guidelines themselves provide the criteria. A procedure would greatly simplify and automate USI evaluation. It would identify and define the roles of guidelines dimensions such as abstraction, generality, and examples usage.

The second conclusion that can be derived from the experiment is that guidelines need to be reworked to minimize levels of abstraction as much as possible. Minimizing abstraction reduces uncertainty and promotes concensus in USI design and evaluation. It also makes guidelines easier to use by novice USI designers and evaluators.

Although the responses to questionnaire 2 indicate that the subjects thought that guidelines were definitely of use in evaluating the prototyped USIs, the subjects found less than half of the violations built into the prototypes. This suggests that more work needs to be done to make USI guidelines easier to use. This is especially true for the abstract guidelines.

NOTES FOR FUTURE RESEARCH

The role of USI design experience in interface evaluation needs to be explored. Do experienced USI designers perform any better than inexperienced designers in detecting abstract or concrete guidelines? If so, can this expertise be passed on to new designers? Can novice designers armed with USI guidelines perform as well as experienced designers?

Although the thesis shows that use of online guideline systems is more time consuming for novice designers than use of hardcopy manuals, the online system offers the capability of providing dynamic, interactive prototypes as examples. The impact on USI design of embedding the dynamic examples, automated USI metrics, and expert consultation need to be explored, since rapid prototyping systems such as RIPL are currntly being developed to that end.

COMMENT ON USI TRAINING IN THE UNIVERSITY

The high variance in the number of embedded violations found by the subjects indicate a nonuniform level of USI design expertise of the senior computer science majors at Virginia Tech. The mean number of concrete violations found by the subjects was less than half of the 21 embedded guideline violations. The subjects averaged even less for the prototype embedded with abstract guideline violations, finding only a fourth of the embedded USI problems. Of the people willing to participate in the experiment, only three were turned down for over qualification. All three had industrial experience in USI design. Since Virginia Tech's computer science curriculum can be considered representative of most computer science curriculums, this points out an academic deficiency in our education system. USI design is estimated to take up as much as one third of the time and resources of software design. The computer science seniors are the next generation of software designers. It is to the benefit of users to make sure that those seniors have a strong understanding of USI design issues.

APPENDIX A

Appendix A-1 USI Guidelines Violated in the Practice 1 Prototype (Smith and Mosier, 1984)

Guideline Number: **Guideline Violations:**

2.1.1-3 Conventional Use of Mixed Case

Display running text (prose) conventionally, in mixed upper and lower case.

Free form running text is only in upper case.

2.1.1-4 Separation of Paragraphs

Separate displayed paragraphs by at least one blank line.

Paragraphs of prose are not separated by blank lines.

2.1.1-1 Conventional Text Display

Computer-generated displays of stored textual data, messages, or instructions, should generally follow design conventions for printed text.

The text display is in double column format like a newspaper rather than like a book as most people would expect a manual to be.

Appendix A-2 USI Guidelines Violated in the Practice 2 Prototype (Smith and Mosier, 1984).

Guideline Number: **Guideline Violations:**

4.3-6 Neutral Wording for Error Message

Adopt Neutral wording for error messages; do not imply blame to the user, or personalize the computer, or attempt to make a message humorous.

The error message "ERROR-Paging Violation. You are illegally trying to scroll past top of list." is displayed to the user if he or she trys to scroll past top of list.

2.1.2-13 Partitioning Long Data Items

Divide long data items of arbitrary alphanumeric characters into subgroups of three or four characters seperated by a blank (or by some special symbol.)

The phone numbers and social security numbers in the database are not partitioned into subgroups.

2.1.3-7 Tables Referenced by First Column

When tables with multiple columns are used for reference, display reference items, i.e., those by which the table will be accessed, in the left column; display the material most relevant for user response in the next adjacent column; and display associated but less significant material in columns further to the right.

Comment: As a corollary, when a list of people is ordered alphabetically by their last name, then their last names should be displayed first, i.e., as the leftmost element in each row

The list is ordered by employee names. However, the phone numbers are in the first column, followed by the names. The names are also first name, middle initial and last name format.

Appendix A-3 Concrete USI Guidelines Violated in Prototype1 (Smith and Mosier, 1984).

Guideline Number: **Guidelines Violations:**

1.0-26 Upper/Lower Case Equivalent
For coded data entry, treat upper and lower case letters as equivalent.

In the prototype, the coded command entry makes use of upper/lower case to differentiate abbreviated command. For instance, "u" is used as the abbreviation for the command to scroll up one line, whereas "U" is used as the abbreviation for the command to page up.

2.1.3-5 Justification of Alphabetic Data
Left justify columns of alphabetic data to permit rapid scanning.

Account holders' names in the main window are right justified.

2.1.1-19 List ordering in multiple columns
If a list is displayed in multiple columns, order the items vertically within each column.

The list of customers displayed in the main window is ordered left to right in double column format.

2.1.3-14 Consistent Column Spacing
Column spacing should be consistent within a display, and from one display to another.

Column spacing in the main window is not consistent, i.e. spacing between the accounts numbers and name columns is not consistent; nor is column spacing in the window consistent with that found in the the main accounts window.

Appendix A-3 Continued

Guideline Number:	Guidelines Violations:
2.3-5	Page Labeling In multi-paged displays, label each page to show its relation to the others. Although the main window is multipaged, no page numbering scheme is used.
2.4-32	Blinking Marker Symbols When a user must read an item that is blink coded, consider adding an extra symbol such as an asterisk to mark the item, and blinking that marker symbol rather than blinking the item itself. The name and number of the customer selected in the main window is blink coded.
3.1.3-12	Letter Codes for Menu Selection If menu selection must be made by keyed codes, design each code to be the initial letter or letters of the displayed option label, rather than assigning arbitrary letter or number codes. The first letter for the "PageD" command is not used as its abbreviated code. "D" is used as the abbreviated code.
2.1.2-3	Data Field Labeling Identify each data field with a displayed label. The data fields for annual percentage interest rate and loan length are not labeled.
2.1.3-3	Labeling units of measurement In tabular displays, either consistently include the units of displayed data in the column labels, or else place them after the first row entry. Not all columns have measurements, for example, balance on accounts is not labeled as dollars and cents.

Appendix A-3 Continued

Guideline Number: Guidelines Violations:

2.1.3-4 Justification of Numeric Data

Justify columns of numeric data with respect to a fixed decimal point; if there is no decimal point, then numbers should be right-justified.

Balances for the accounts are left justified.

`3.0-11 Feedback for Control Entries

The computer should acknowledge every control entry immediately; for every action by the user there should be some apparent reaction from the computer, either by:

(1) execution of a requested transaction if that produces immediately apparent results, or
(2) a message indicating completion of the transaction, or
(3) a message indicating that execution is in progress or deferred, or
(4) a message indicating that the control entry requires correction or confirmation.

If an entry by the user is not recognized as a valid command entry, no action is taken. In opening the accounts window, a delay of several seconds occurs. During this delay, the screen is not updated or a wait message given.

2.1.1-14 Active Voice

Compose sentences in the active rather than passive voice.

Help message is written in passive voice, i.e. "Editing a data field is done by using the CHANGE command."

2.1.1-5 Consistent Word Spacing

Displayed text should be left-justified to maintain consistent spacing between words, leaving right margins ragged if that is the result.

Help information is both left and right justified.

Appendix A-3 Continued

Guideline Number: Guidelines Violations:

3.1.3-13 Consistent Coding of Menu Options

If letter codes are used for menu selection, use them consistently in designating options from one transaction to another.

The command "pageU", abbreviated "U" is used for paging up in the main window, the command "Page" abbreviated "P" is used in all other windows to handle both paging up and down. Similarly, scrolling up is abbreviated "u" in the main window and "U" in all other windows.

3.1.3-17 Consistent Display of Menu Options

When menus are provided in different displays, design them so that option lists are consistent in wording and ordering.

Menu options in the help window are in arbitrary order is different from the order used in the other windows. The commands "Exit" and "Quit" in the help and accounts windows perform the identical function of exiting the user out of the current window.

2.1.3-10 Numbered Items Start with "1"

When listed data items are labeled by number, start the numbering with "1", rather than "0".

Items in the personal data window start numbering at "0" rather than "1."

2.3-9 Display Title at Top

Begin every display with a title or header, describing briefly the contents or purpose of the display; leave at least one blank line between the title and the body of the display.

The personal window has no title.

Appendix A-3 Continued

Guideline Number:	Guidelines Violations:
2.3-10	Command Entry, Prompts, Messages at Bottom. Reserve the last several lines at the bottom of every display for status and error messages, prompts and command entry. The personal window has message and command fields at the top of the display.
3.1.3-8	Standard Area for Code Entry When menu selection is accomplished by code entry, provide a standard command entry area (window) where users enter the selected code; place that entry area in a fixed location on all displays. The command line for the personal data window is at the top of the window, while those for all other windows are at the bottom.
1.8-3	Display of Default Values On initiation of a data entry transaction, display currently defined default values in their appropriate data fields. Certain data entry fields have default values, for instance, the default for citizenship in the personal data window is USA. However, default values are not disclosed to the user.
3.1.5-21	Reviewing Destructive Commands When command entries may have disruptive consequences, require users to review and confirm a displayed interpretation of the command before it is executed. In saving a file, the command that disk space may have been exceeded is screened, however, no confirmation from the user is be sought.

Appendix A-4 Abstract USI Guidelines Violated in Prototype2 (Smith and Mosier, 1984).

Guideline Number:	Guidelines Violations:
4.3-5	Brief Error Messages Make error messages brief but informative. Error messages are verbose and ambiguous.
2.5-3	Meaningful Display Labels The display identification label should be unique, short, but meaningful enough to be remembered easily. Main Window has a complex title: "Dominion National Bank Customer Accounts and Personal Information Relational Database."
3.1.5-7	Distinctive Wording of Commands Design words in a command language to be distinctive from one another, and emphasize differences in function. The command word "Record" is used to open the accounts window and the command word "File" is used to exit the database.
2.0-11	Familiar Wording The wording of displayed data and labels should incorporate familiar terms and the technical jargon of the users, and avoid the unfamiliar jargon of designers and programmers. "Virtual address" is a label that a programmer would use instead of a bank accounts manager who would use a label such as "Customer Accounts."
4.0-23	Easy Way to Get Guidance Permit users to switch easily between any information-handling transaction and the associated guidance material. To access Help the user needs to type the string PF1 "H" PF1.

Appendix A-4 Continued

Guideline Number:	Guidelines Violations:
2.0-1	Necessary Data Displayed At any step in a transaction sequence, ensure that whatever data a user needs will be available for display. The means of accessing the help information is not given.
2.1.1-8	Clarity of Wording In designing text display, especially text composed for user guidance, strive for simplicity and clarity of wording. Help information is ambiguous with complex structure.
2.1.1-6	Minimal Hyphenation In display of textual material, keep words intact, with minimal breaking by hyphenation between lines. The Help message has may hyphenations, including one between two pages.
2.1.1-10	Simple sentence structure Use short, simple sentences. Help text has multi-claused sentences.
2.0-2	Only Necessary Data Displayed Tailor the display of data to user needs, providing only necessary and immediately usable data at any step in a transaction sequence. The help message gives information not only on how to open the personal window but also information on the commands used in the personal window. If the commands are used in other windows, the way they are used in other windows are also in the help message.

Appendix A-4 Continued

Guideline Number:	Guidelines Violations:
2.3-2	Distinctive Display Elements Make different elements of display formats clearly perceptible to users, and distinctive from one another. The message and command fields in the personal window are not separated from the data lines by a blank line or any other means, nor are they coded in any way, other than by content to differentiate them from the data.
1.4-14	Distinctive Label Format Make labels for data fields distinctive so that they will not be readily confused with data entries, labeled control options, guidance messages, or other displayed material. Martha Washinton is not separated by the field label by a colon. Also field labels are not highlighted or in all uppercase to differentiate them from data fields.
1.4-17	Informative Labels In labeling data fields, employ descriptive wordings, or else standard, predefined terms, codes and/or abbreviations; avoid arbitrary codes. Several labels will not be very descriptive, such as "Bl/BR/Rd/"for hair color and "L/A/H:" for low/average/and high risk. Also, the accounts window uses column labels such as "Life" and "Amount" for loan duration and loan amount.
1.4-20	Familiar Units of Measurement Employ units of measurement that are familiar to the user. Weight and height for the customers are given in grams and meters. User expectations will be for pounds and feet and inches.

Appendix A-4 Continued

Guideline Number:	Guidelines Violations:
2.1.2-2	Visually Distinctive Data Fields Display formats should provide clear visual definition of different data fields. Several data fields are on the same line.
2.1.2-6	Distinctive Wording of Labels Ensure that field labels are distinctive from one another in wording to aid user discrimination. Several labels are not very discriminative, such as "Phone_H" for home phone number and "Phone_W" for work phone number.
2.1.2-9	Labels Close to Data Fields Ensure that labels are sufficiently close to be associated with their data fields, but are separated from their data fields by at least one space. Some data fields are far from their labels while others are only separated by a colon.
2.1.3-6	Logical Organization Organize tabular data in some recognizable order to facilitate scanning and assimilation. Tabular data are not well organized. Several data fields are on the same line but not sperated into noticeable, regular columns in the personal window. The accounts information are not organized in any noticeable order by account type. It should be alphabetically listed.

Appendix A-4 Continued

Guideline Number:	Guidelines Violations:
3.0-8	Distinctive Display of Control Information Design all displays so that features relevant to sequence control are distinctive in position and/or format. The command lines as well as command prompts differ across windows. The HELP window uses "??" and ">>" as the command prompt and message label. The main and accounts information windows use "Commands???" and "Messages>>>" as prompts and message labels. The personal window uses "Comm:??" and "Mess:>>" which are not separated from the displayed data.
2.4-3	Meaningful Codes Adopt meaningful or familiar codes, rather than arbitrary codes. The command to open the personal information window is "r" for RECORD. Month is abbreviated "mm," and annual interest rate is abbreviated "AIR."
2.4-1	Highlighting Critical Data Provide distinctive coding to highlight important data items requiring user attention, particularly when those items are displayed infrequently. The disk full message and confirmation query will not be highlighted in any way. It will appear in the message field like any other message.

APPENDIX B

Appendix B-1 Introduction to the User System Interface Guidelines

The user interface encompasses all means of communication between the user and a computer system. The goal of an interface is to make the system easy to learn and use. Also, since communication between user and system is never completely error free, the system needs to be robust and safe enough to handle entry errors. To aid software engineers in the design of user system interfaces, human factors engineers have been developing user system interface design guidelines. These guidelines take knowledge gleaned from psychology, ergonomics, computer science, and human factors and apply it to the design of the front ends of computer systems.

The set of user system interface (USI) guidelines that you will be using are separated into four sections as determined by functionality. However, these sections are not completely distinct in that some guidelines are duplicated in different sections. The four sections are organized as follows:

Section 1: Data Entry.
Data entry refers to user actions involving input of data to a computer system, and the responses of the system to such inputs. Although data entry touches upon command entry, the bulk of the information in this section deals with user input of data and not commands. Therefore, this section considers such topics as editing data and text input, form filling, and tabular data entry.

Section 2: Data Display.
Data display refers to computer output of data to a user, and user's assimilation of information from such outputs. Guidelines in this section may help in formatting and presenting data to maximize users' information comprehension and retention. This section covers display and formats of text, data forms, tables, as well as data updating and coding.

Section 3: Sequence Control.
Sequence control refers to user actions and/or computer logic that initiate, interrupt, or terminate transactions. It governs the transition from one transaction to the next. The scope of this section covers user system dialogue types such as questions and answers, form filling, menu selection, command languages, and other methods of controlling the system's transactions. Error management is also covered.

Section 4: User Guidance
User guidance refers to error messages, alarms, prompts, and labels as well as help facilities to guide a user's interaction with the computer. The fundamental objective of user guidance is to promote efficient use with minimal memory load on the user and hence minimal system learning time. This section discusses such topics as error and routine feedback and system status information.

The guidelines attempt to be all encompassing, in effect covering the entire realm of possible interfaces. Therefore, it is left to you to select the guidelines you feel apply to a specific user interface. The guidelines themselves are worded in broad terms to permit broad application.

If you have any questions on user system interface guidelines, please ask the experimenter at this time.

Appendix B-2 The User System Interface Guidelines Set Organization

The set of user system interface guidelines that you will be using is organized in a manual into four sections on the basis of functionality. The four sections are the following:

section 1 deals with data entry;
section 2 with data display,
section 3 with sequence control,
and section 4 with user guidance.

Table of Contents and Section Introductions:

At the beginning of the manual is a table of contents that lists the major sections and subsections found in the manual, as well as the page number corresponding to the beginning page of each section or subsection.

Each section begins with a short introductory discussion of design issues relating to the general functional area. This introduction is approximately four pages long and provides a general overview of the section and discusses certain concerns about the theme of that section. The introduction concludes with brief definitions of the various user interface functions covered in that section of the guidelines, along with a table of contents listing the major subsections specific to that section.

Guidelines:

Under any function there will usually be guidelines pertaining to various subordinate topics. The organization of the guidelines can be seen in the accompanying snapshot provided. The circled number pointing to the elements of the example correspond to the numbers of the following explanation.

Insert Snapshot 1 Here

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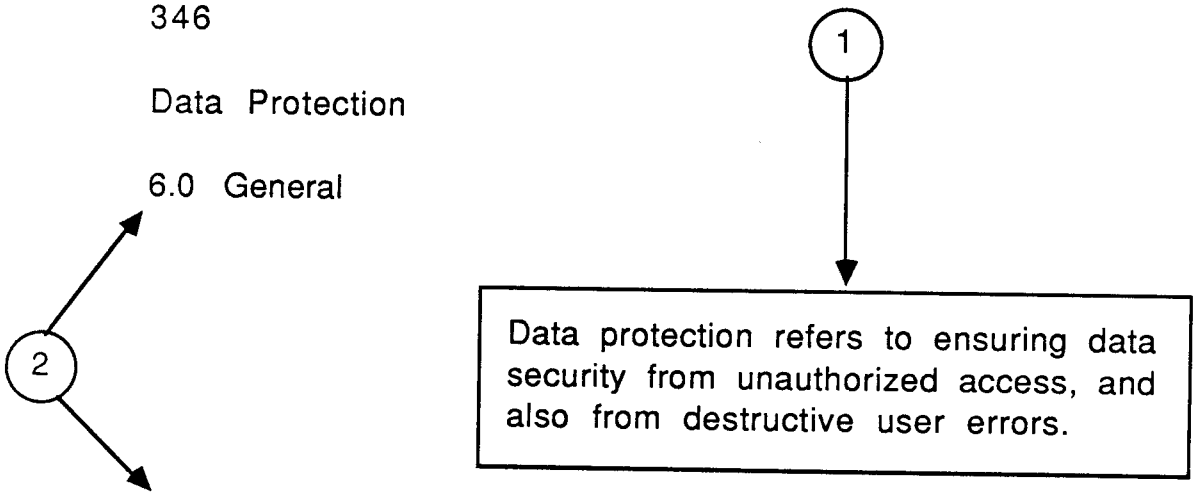
Data Protection

6.0 General



-1 o Feedback for Mode Selection

When the result of user actions will be contingent upon prior selection among differently defined operational modes, provide a continous indication of the current mode, particularly when user inputs in that mode might result in unintended data loss.

3

4 Example: If a DELETE mode is used to edit displayed data, some indication of that mode should be displayed to users.

6 Comment: A user cannot be relied upon to remember prior actions. Any action whose results are contingent upon previous actions represents a potential threat to data protection.

7 Reference: BB 4.3.4; MS 5.15.5.5.

8 See also: 4.2-8, 6.5-13

-5 o Continuous Recognition of User Identity -5

Once a user's identity has been authenticated, whatever data access/change privileges are authorized for that user should continue throughout a work session.

5 Exception: In special instances a user's data access/change privileges might reasonably change as a result of succeeding transactions, e.g., if computer analysis indicated suspicious or otherwise abnormal behavior.

See also: 3.3-10, 6.2-1, 6.2-6, 6.3-1.

Snapshot 1. Example of a Smith and Mosier USI guideline page

1) Functional definitions are repeated in boxed format to begin the listing of guidelines under each function. These definitions should aid reader understanding of the material, and the boxed format will provide a notable visual indicator that a new series of guidelines has begun.

2) The guidelines are numbered sequentially under each function. The numbering scheme used is hierarchical by sections and subsections. The first number indicates a section. In the manual, the sections and subsections that the guidelines are in are given at the top corner of the page, while the number of the guideline under these sections is given before the title. Do not be confused by the section title or numbers in the example. Remember that there are only four major sections that you will be using.

3) Each guideline has been given a short title to indicate its particular subject matter. The guidelines themselves are stated as a single sentence. They are worded as simply as possible, usually in general terms to permit broad application, but sometimes with contingent phrasing intended to define a more limited scope of application.

4) The guidelines may be illustrated by one or more examples. The examples are intended to illustrate the guideline, not limit the interpretation of the guidelines.

5) Some guidelines may also be followed by noted exceptions. The exceptions are intended to limit the interpretation of the guidelines.

6) Also following the exceptions may be supplementary comments that explain the reasoning behind a guideline, or possible ways to interpret the guidelines, or note relations between one guideline and another.

7) Reference citations in letter codes may be given for guidelines that correspond with other published design citations. For this experiment, these citations can be ignored.

8) Lastly, where a guideline is specifically related to another guideline, cross-reference numbers may be given. If the cross-reference indicates a guideline number that does not start with a number less than or equal to 4, please ignore that reference.

Index:

Towards the back of the manual, following Section 4 there is a topical index containing an alphabetical listing of key words. The index is logically grouped with entries containing subentries and cross indexes. The index is intended to help you find guidelines on a particular topic independently of the functional organization imposed by the manual. The page numbers indicating where these topics are discussed in the text are provided.

If you have any questions concerning the organization of the guidelines that you will be using, please ask the experimenter at this time.

Appendix B-3: Trainer on Using the Technical Librarian

Welcome to the MicroVAX II Workstation. Shown on the screen are 2 windows. The top left most window is the technical librarian, an on-line manual containing a set of user interface guidelines. The bottom right most window is the interactive prototype you will be evaluating. Transferring from one window to another is done with the mouse. Firmly grasp the mouse in your left or right hand, whichever you prefer. In this example, the Technical Librarian is the active window. To make the prototype window the active window, move the arrow cursor to the bottom most window. With your index finger, click on the left most button of the three buttons located at the top of the mouse. The rectangular blinking cursor indicates the window that you are working in. You will be required to transfer to and from one window to another while you are evaluating the prototypes interfaces.

The Technical Librarian:

The Technical Librarian is an on-line manual containing a set of user interface design guidelines. You will use these guidelines to help you evaluate two prototyped interfaces. The Technical Librarian has three different modes: the table of contents, the index, and the read modes. The mode that you will be in is indicated by the title at the top of the Technical Librarian window. Each mode has its own set of commands, with easy means of transferring from one mode to another. The commands that can be used in each mode are invoked with a single keystroke that is the first letter of the command word. No carriage return is needed. To move the cursor bar from one header to another, use the "up-arrow" and "down-arrow" key located on the right side of the keyboard.

The Table of Contents:

The table of contents lists major section headings. There are four sections in the Technical Librarian database: data entry, data display, sequence control, and user guidance. Each of these sections in turn has expandable subheadings. A "+" given in front of a section or subsection entry indicates that it is expandable or has subheadings. A "-" indicates that the entry has no subheadings and cannot be expanded further. The commands that you can use in the table of contents mode are the following:

Expand--initiated by the "E" keystroke. It shows the directly subordinate headers of a selected header.

Forward--initiated by the "F" keystroke. It moves forward one page when possible. If you are on the last page and attempt to use the Forward command, a warning beep will sound.

Back--initiated by the "B" keystroke. It moves back one page when possible. If you are on the first page and attempt to page back, a warning beep will sound.

Collapse--initiated by the "C" keystroke. It collapses all expanded subheadings of the selected heading. In order to be collapsed, an entry must have expanded subheadings.

Locate--initiated by the "L" keystroke. Locate searches for a specified string in the table of contents. You will be prompted for a character string. The character string is limited to a maximum of 25 characters. Once you have specified a search string, you will be asked whether to ignore or consider the case of the letters in the string. You will respond by typing either "y" or "n" for YES or NO.

Next--initiated by the "N" keystroke. The Next command searches for the next occurrence of the string specified by the Locate command. If the Locate command was not previously used, you will be prompted for a character string.

Help--initiated by the "H" keystroke. Help displays a window with one line explanations of each of the commands.

Index--initiated by the "I" keystroke. Th Index command transfers you to the "Index" mode.

Read--initiated by the "R" keystroke. It opens the book to the beginning page of the selected header.

Marker--initiated by the "M" keystroke. Marker returns you to the last page that you were reading in the text mode.

Quit--initiated by the "Q" keystoke. Quit will exit you from the Technical Librarian. Do not use this command unless theexperimenter tells you to.

Start--initiated by the "S" keystroke. Start returns the table ofcontents to its initial state where all subheadings of themajor sections are collapsed. Only the major sections are screened.

Note that paging is completely under the control of the user; i.e. if the entry to be expanded is the last entry shown in the window, expanding the window will not automatically page or scroll the window.

The Index Mode:

The index mode is presented in a hierarchical form, much as you would see it in an outline. Only the top level headers or the letters of the alphabet are presented initially. These letters can be expanded to show subheadings listed in alphabetical order. As in the table of contents, headers marked with a "+" indicates entries with subheadings. Note that some index entries may be followed by a number in parentheses. This number indicates that the entry has multiple references. If you use the Read command to reference that topic, you may then use the Subsequent and Prior commands to move back and forth among the references while in the read mode. The commands that you can use in the index mode are the following:

Expand--initiated by the "E" keystroke. It shows the directly subordinate headers of a selected header.

Forward--initiated by the "F" keystroke. It moves forward one page when possible. If you are on the last page and attempt to use the Forward command, a warning beep will sound.

Back--initiated by the "B" keystroke. It moves back one page when possible. If you are on the first page and attempt to page back, a warning beep will sound.

Collapse--initiated by the "C" keystroke. It collapses all expanded subheadings of a selected heading. In order to be collapsed, an entry must have expanded subheadings.

Locate--initiated by the "L" keystroke. Locate searches for a specified string in the index. You will be prompted for a character string. The character string is limited to a maximum of 25 characters. Once you have specified a search string, you will be asked whether to ignore or consider the case of the letters in the string. You will respond by typing either "y" or "n" for YES or NO.

Next--initiated by the "N" keystroke. The Next command searches for the next occurrence of the string specified by the Locate command. If the Locate command was not previously used, you will be prompted for a character string.

Help--initiated by the "H" keystroke. Help displays a window with one line explanations of each of the commands.

TOC--initiated by the "T" keystroke. Th Index command transfers you to the table of contents mode.

Read--initiated by the "R" keystroke. It opens the book to the beginning page of the selected header.

Marker--initiated by the "M" keystroke. Marker returns you to the last page that you were reading in the text mode.

Quit--initiated by the "Q" keystoke. Quit will exit you from theTechnical Librarian. Do not use this command unless the experimenter tells you to.

Start--initiated by the "S" keystroke. Start returns the index to its initial state where all subheadings of the major sections are collapsed. Only the alphabetical listing is screened.

The Read Mode:

Pages of text are presented 19 lines at a time in the read mode. The read mode can be accessed from both the table of contents and the index mode. The command menu is displayed at the bottom of the window. Like the table of contents, paging is handled by the Forward and Back commands. Scrolling up and down one line can be done by using the "up-arrow" and "down-arrow" command. These keystrokes will scroll the text one line in the window. The read mode is a browsing system; i.e. although you can enter the text at distinct points from the table of contents and index modes, if you started at the first page, you can read text to the end of the manual. The following additional commands are available in the text mode:

Forward--initiated by the "F" keystroke. It moves forward one page when possible. If you are on the last page and attempt to use the Forward command, a warning beep will sound.

Back--initiated by the "B" keystroke. It moves back one page when possible. If you are on the first page and attempt to page back, a warning beep will sound.

Help--initiated by the "H" keystroke. Help displays a window with one line explanations of each of the commands.

Index--initiated by the "I" keystroke. The Index command transfers you to the index mode.

Subsequent--initiated by the "S" keystroke. If the text mode

was entered from the index mode with an entry that has multiple references and you wish to access subsequent references, this command will advance you to the next reference. Remember that in the index numbers in parenthesis indicate entries with multiple references.

Prior--initiated by the "P" keystroke. If the text mode was entered from the index mode with an entry that has multiple references and you have accessed subsequent references, this command will return you to the prior reference.

TOC--initiated by the "T" keystroke. The TOC command transfers you to the table of contents mode.

Quit--initiated by the "Q" keystoke. Quit will exit you from the Technical Librarian. Do not use this command unless the experimenter tells you to.

APPENDIX C

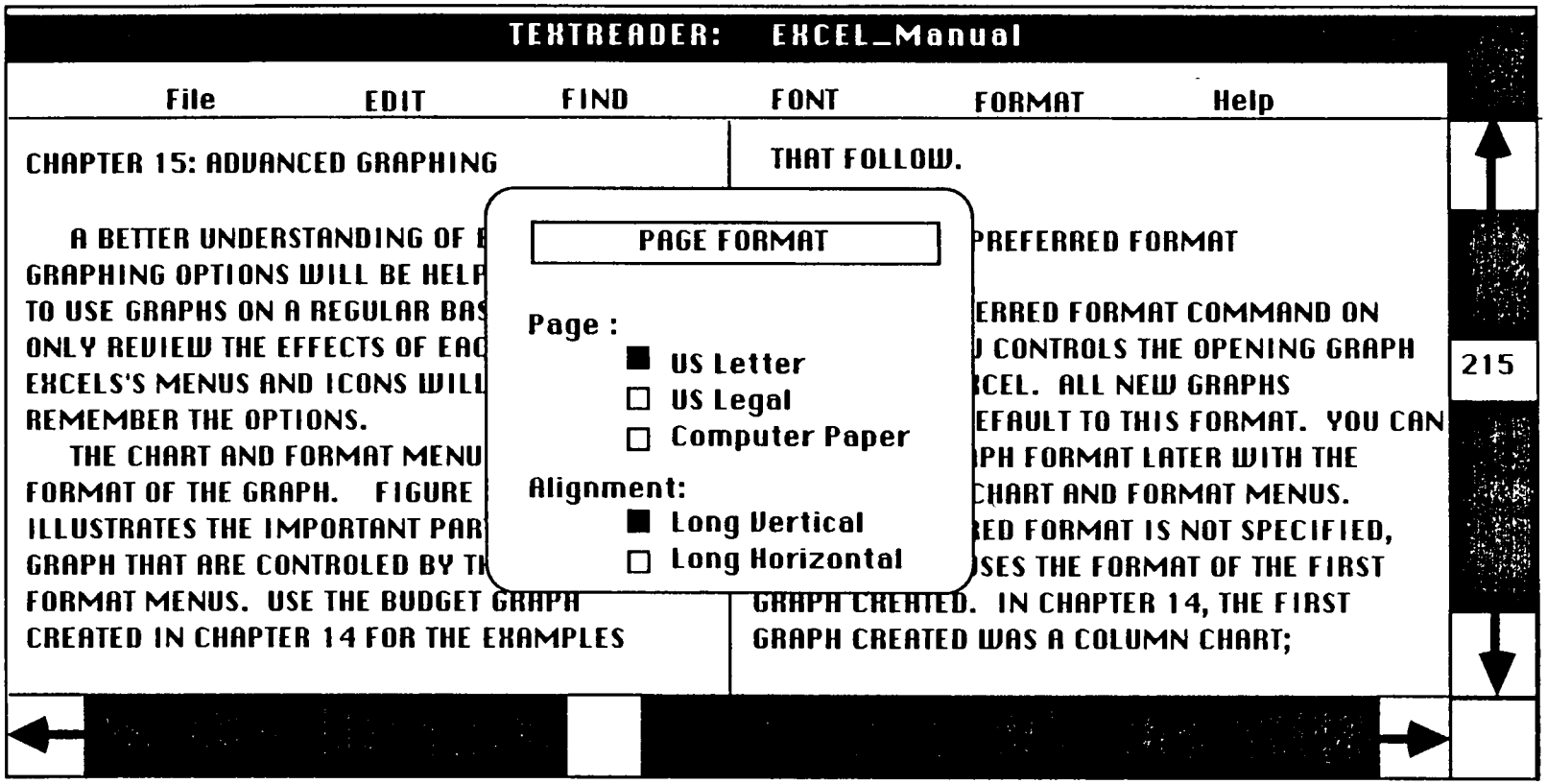
Appendix C-1 Practice Prototype 1 evaluation instructions

Please remember to use the user interface guidelines set that you were given as a design tool. Also, please remember to verbalize as you evaluate the interface.

Shown on the screen is a snapshot of a user system interface for a browsing, online textbook. Assume that you are a casual user (non-programmer) who is learning how to use MicroSoft Excel. The simulated interface is mouse driven with scroll bars at the left and bottom of the window. It has a pull down menu list located at the top of the window under the title line. At present, a pop-up window has been activated that was resident under the FORMAT menu. You are attempting to format the pages of text for print out. The interface is non-interactive; therefore, it will not respond to any entry you make.

This interface has from 0 to 10 user system design violations. Please evaluate this static prototype using the set of user system interface design guidelines with which you were provided as a tool. If you see any problems in this interface, record them on the sheet of paper provided. For each problem that you list, indicate how confident you are that the guideline was violated and your opinion on how critical this violation is to the interface. Use a 1 (least confident, or critical) to 5 (most confident, or critical) scale. You will have 15 minutes to complete your evaluation of this interface. If you have any questions at any time during this session, please ask the experimenter.

Insert Panel A Here



Panel A. Snapshot of the USI for the first practice prototype.

Appendix C-2 Practice Prototype 2 evaluation instructions

This interface has from 0 to 10 user system design violations. Please evaluate this static prototype using the set of user system interface design guidelines with which you were provided as a tool. If you see any problems in this interface, record them on the sheet of paper provided. For each problem that you list, indicate how confident you are that the guideline was violated and your opinion on how critical this violation is to the interface. Use a 1 (least confident, or critical) to 5 (most confident, or critical) scale. You will have 15 minutes to complete your evaluation of this interface. If you have any questions at any time during this session, please ask the experimenter.

Please remember to use the user interface guidelines set that you were given as a design tool. Also, please remember to verbalize as you evaluate the interface.

> You are a manager of a small business. You use the shown database to keep a list of employees, their phone numbers, addresses and social security numbers. You are not a programmer.
>
> Type "b" to page back.
>
> Read the social security number of Peter T. Cromer.
>
> Type "l" to use the LOCATE command.
>
> In response to the prompt, enter "McAllister" and RETURN.
>
> Read the phone number of Edward C. McAllister.
>
> Type "q" to quit the session.

Examine the display carefully and review the actions that you have performed. If you feel that a USI design guideline was violated in the interface, please record it on the form provided and indicate your confidence and the criticality of the violation. Remember that from 0 to 10 guidelines may be violated in this task unit. Once you have finished, please inform the experimenter.

Insert Panel B Here

DATABASE: Personnel Addresses

PHONE	NAME	SS Number	ADDRESS
(303) 4641211	Mark G. Lucas	327154102	3512 Cicero Dr., Apt. 45 New Carrolton, MD 24433
(303) 4661231	Margaret H. Mannon	236745232	0718 Brandersmill Rd. New Carrollton, MD 24431
(303) 463312	Edward C. McAllister	343123345	456-C Storm Hill Apt. Laurel, MD 23412
(303) 4661244	Timothy F. Morgan	123123956	2152 Edwards Dr., Apt. 34-C Laurel, MD 23412
(303) 3447455	Julie C. Muneir	371221233	221 Browder St., New London, MD 28872
(303) 4468799	Roger H. Nance	451092206	2451 Connely Av., Apt. 12

PAGE BACK LOCATE SORT ADD DELETE FORMAT PRINT QUIT

Commands:??

Panel B. Snapshot of the USI for the second practice prototype.

Appendix C-3 Prototype I Scenario

The actions that you are to perform in this interactive evaluation scenario are given below. Please perform these actions, and only these actions specified in the scenario, as they will step you through the interface of the database. The prototypes are separated into 5 distinct task units or units that you will be evaluating. Tell the experimenter when you are finished with a unit so you can proceed to the next unit. You will have as much time as needed to complete your evaluation. While going through each unit, record on the form provided as many problems in the user system interface as you can find. There will be between 0 to 10 guideline violations in each unit. Remember to use the user system interface design guidelines that were given to you as a tool in helping you make your evaluation. Also, for each problem that you list, indicate how confident you are that the guideline was violated and your opinion on how critical this violation is to the interface. Use a 1 (least confident, or critical) to 5 (most confident, or critical) scale.

You have as much time as needed to evaluate each unit. Note however that the actions you perform allow you to traverse through the prototype only in the sequence given in this scenario. Therefore, take as much time as you need to evaluate the display or the results of your actions before performing your next action.

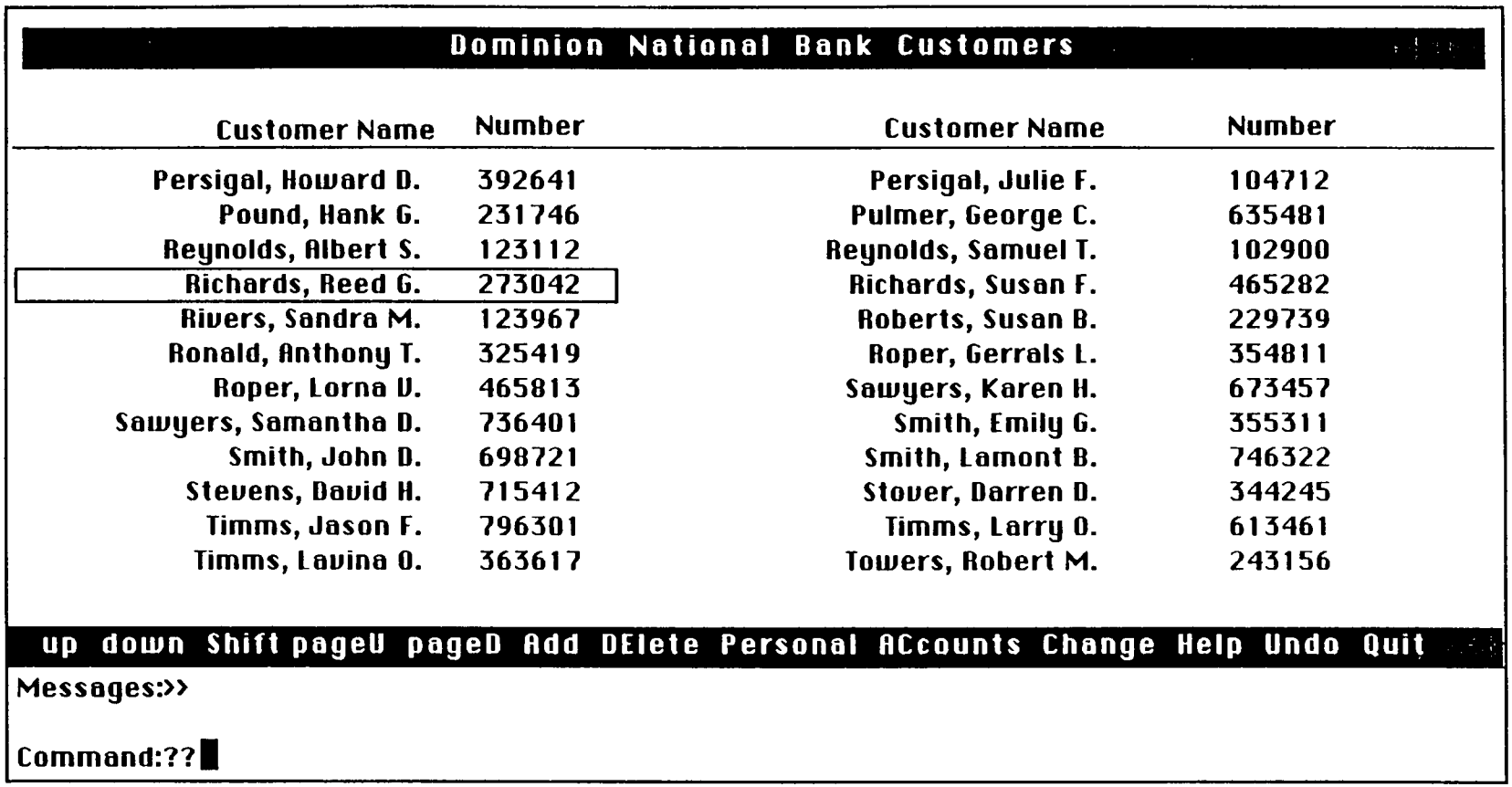
Unit C1:

Please remember to use the guidelines set that you were given as a tool in your evaluation. Also, please remember to verbalize as you evaluate the interface.

> Welcome to the Dominion National Bank Customer Accounts database. As a customer accounts manager, you will use the database to keep a complete and up-to-date listing of all customer transactions, checking and savings accounts, and loans.
>
> You are in the main window of the Dominion National Bank Customer Accounts database. You wish to open the record of a customer named Reed Richards. Reed Richards is not in the screened portion of the listed names. Type the sequence of "U" and RETURN in the command entry field. An error message will be screened in the message line indicating that you cannot page past the top of the page.
>
> Type the sequence "D" and RETURN twice to advance forward two pages.
>
> The entry for Reed Richards is in the first column of the displayed page, fourth line from the top of the text display. Type "d3" and RETURN in the command entry line to move the blinking selection marker to the desired entry.

Before advancing to the next unit, again examine the display carefully and review the actions that you have performed. If you feel that a USI design guideline was violated in the interface, please record it on the form provided and indicate your confidence and the criticality of the violation. Remember that from 0 to 10 guidelines may be violated in this task unit. Once you have finished, please inform the experimenter before going on to the next task unit.

Insert Panel 1.1 Here



Panel 1.1 First snapshot from the instruction set of prototype 1.

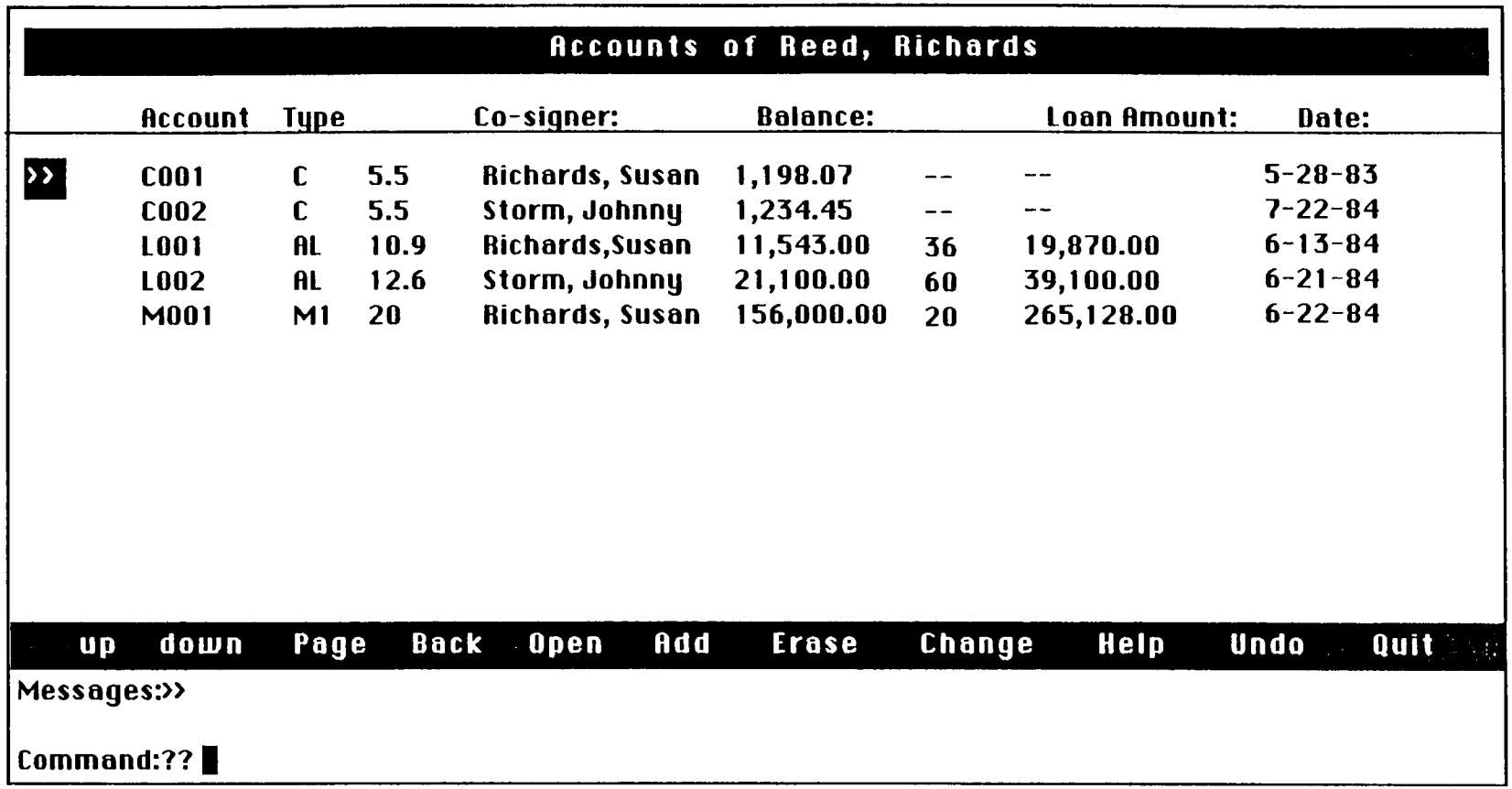
Unit C2:

Please remember to use the guidelines set that you were given as a tool in your evaluation. Also, please remember to verbalize as you evaluate the interface.

> You wish to see the accounts held by Reed Richards. Therefore, you type in "ac" for the "ACcounts" command. The screen is updated with the Accounts window. Once the window is displayed, look up the annual interest rate and the balance for account L002.

Before advancing to the next unit, again examine the display carefully and review the actions that you have performed. If you feel that a USI design guideline was violated in the interface, please record it on the form provided and indicate your confidence and the criticality of the violation. Remember that from 0 to 10 guidelines may be violated in this task unit. Once you have finished, please inform the experimenter before going on to the next task unit.

Insert Panel 1.2 Here



Panel 1.2 Second snapshot from the second instruction set of prototype 1.

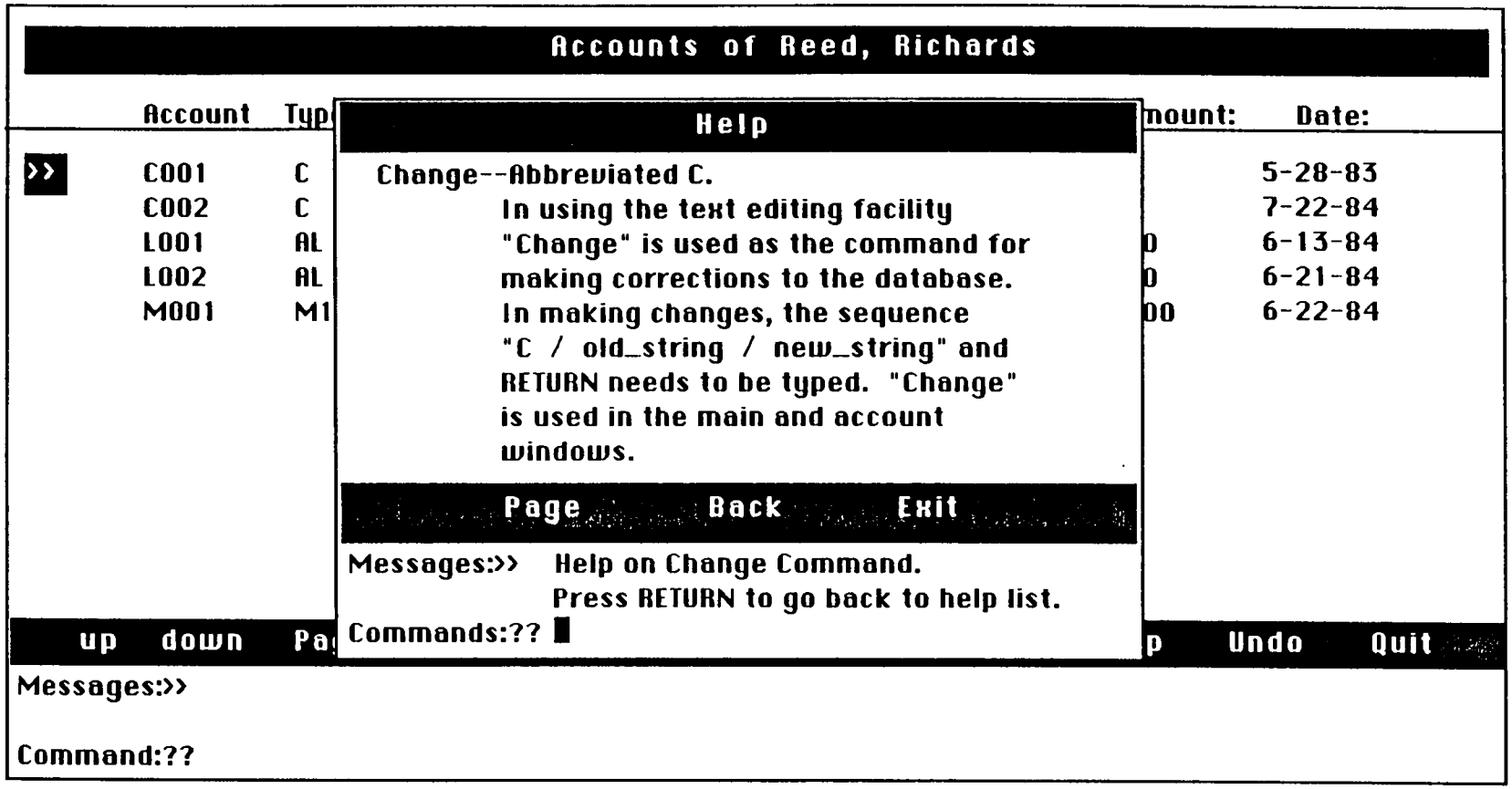
Unit C3:

Please remember to use the guidelines set that you were given as a tool in your evaluation. Also, please remember to verbalize as you evaluate the interface.

> You wish to find help information in using the "Change" command; therefore, you type "h" and RETURN for "Help." The small help window is displayed in the middle of the screen.
>
> Scroll down to the "Change" command in the screened list by typing "d3" and RETURN.
>
> Press "r" and RETURN. Read the help information displayed.

Before advancing to the next unit, again examine the display carefully and review the actions that you have performed. If you feel that a USI design guideline was violated in the interface, please record it on the form provided and indicate your confidence and the criticality of the violation. Remember that from 0 to 10 guidelines may be violated in this task unit. Once you have finished, please inform the experimenter before going on to the next task unit.

Insert Panel 1.3 Here



Panel 1.3 Third snapshot from the instruction set of prototype 1.

Unit C4:

Please remember to use the guidelines set that you were given as a tool in your evaluation. Also, please remember to verbalize as you evaluate the interface.

Once you have evaluated the help display, return to the accounts window by typing "e" for "Exit" and RETURN.

You decide that the accounts window does not need editing and you need to return to the main window. Type "q" for "quit" and RETURN. The system will respond put you in the main window.

You will now update personal information of a customer named Clark Kent . Clark Kent must be found in the list of customers in the main window. Type "U" and RETURN twice to page up the list.

Clark Kent will be in the first column of the sixth row in the displayed page. Type "d5" and RETURN to select Clark Kent.

Type "p" and RETURN to get the customer's personal information.

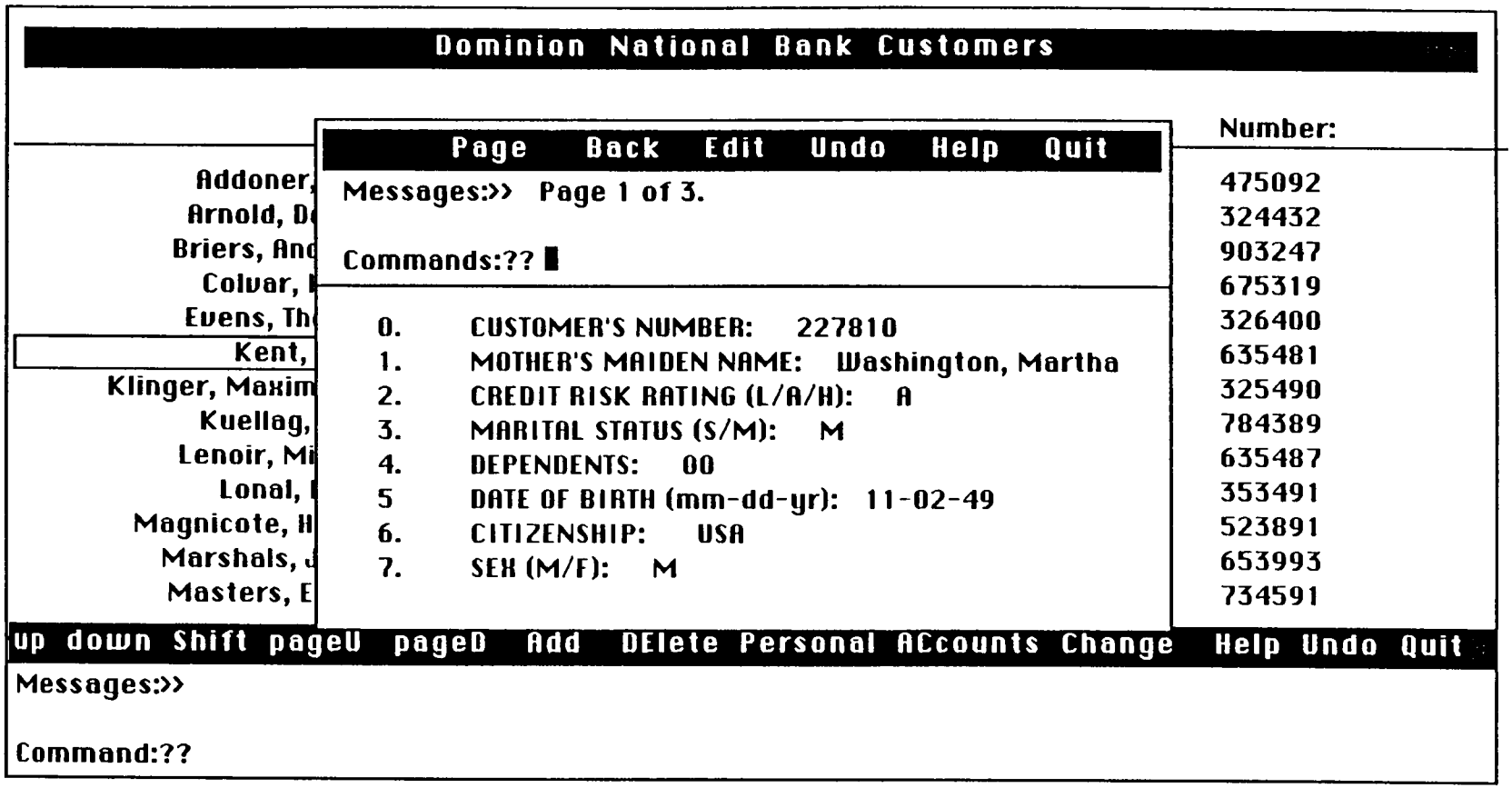
You will edit the personal information data by typing the string "e", a number, and then RETURN. You will be prompted for the information that you are changing. Change credit rating ("e2" and RETURN) to "A" for average risk (respond to the prompt by entering RETURN).

Change marital status ("e3" and RETURN) to married (respond to the prompt by typing "m" and RETURN).

Change citizenship ("e6" and RETURN) to USA (respond to the prompt by just entering RETURN).

Before advancing to the next unit, examine the display carefully and review the actions you have performed. If you feel that a USI design guideline was violated in the interface, please record it on the form provided and indicate your confidence and the criticality of the violation. From 0 to 10 guidelines may be violated in this task unit. Please inform the experimenter before proceeding to the next task unit.

Insert Panel 1.4 Here



Panel 1.4 Fourth snapshot from the instruction set of prototype 1.

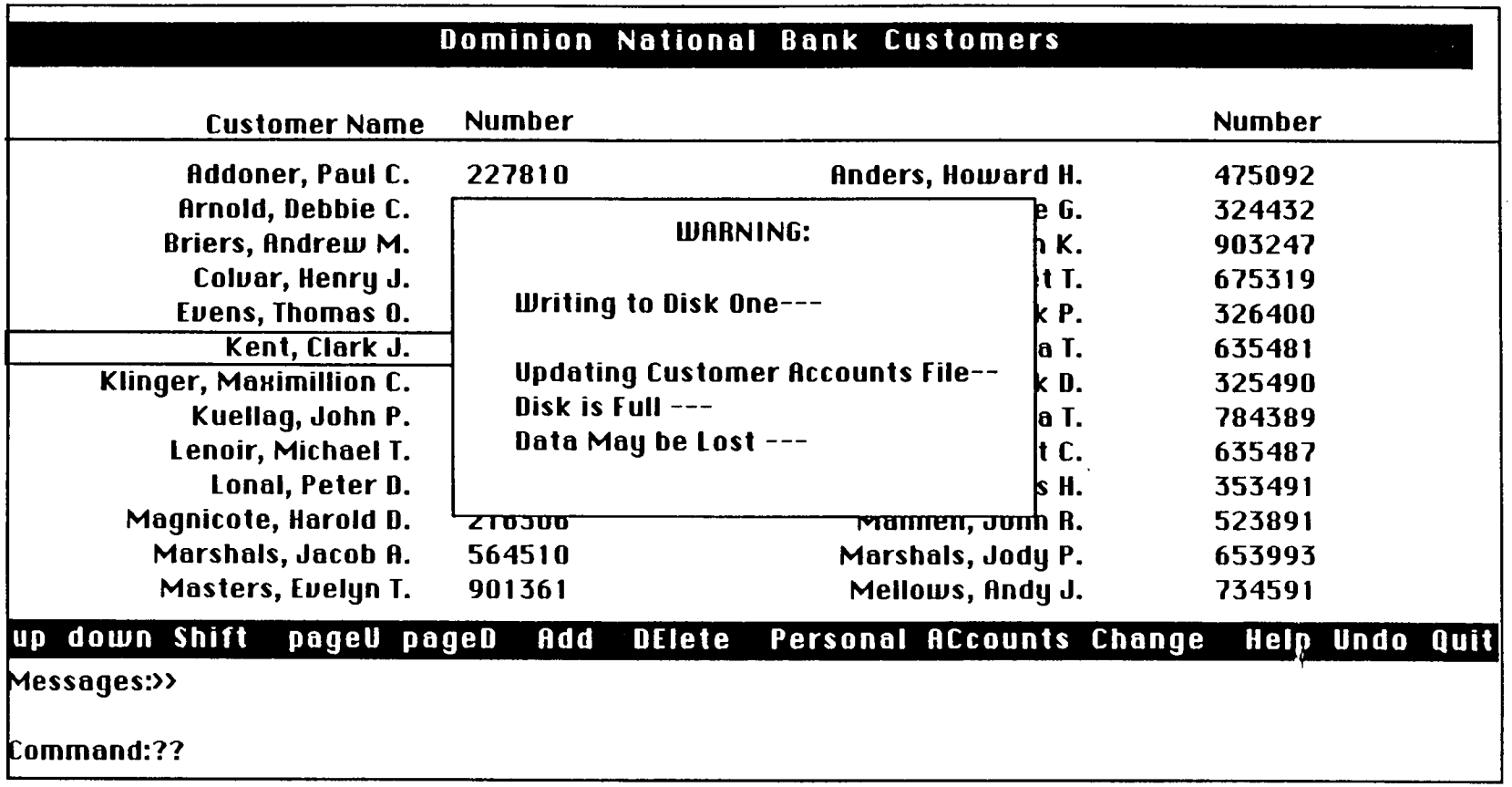
Unit C5:

Please remember to use the guidelines set that you were given as a tool in your evaluation.Also, please remember to verbalize as you evaluate the interface.

> Once the changes have been made, you can return to the main window by typing "q" and RETURN for "Quit."
>
> You are now ready to quit the session by typing "q" and RETURN. Read the message that is screened to you.

Again examine the display carefully and review the actions that you have performed. If you feel that a USI design guideline was violated in the interface, please record it on the form provided and indicate your confidence and the criticality of the violation. Remember that from 0 to 10 guidelines may be violated in this task unit. Once you have completed this task, go see the experimenter for the next step in the experiment.

Insert Panel 1.5 Here



Panel 1.5 Fifth snapshot from the instruction set of prototype 1.

Appendix C-4 Prototype 2 Scenario

The actions that you are to perform in this interactive evaluation scenario are given below. Please perform these actions, and only these actions specified in the scenario, as they will step you through the interface of the database. The prototypes are separated into 5 distinct task units or units that you will be evaluating. Tell the experimenter when you are finished with a unit so you can go to another unit. You will have as much time as needed to complete your evaluation. While going through each unit, record on the form provided as many problems in the user system interface as you can find. There will be between 0 to 10 guideline violations in each unit. Remember to use the user system interface design guidelines that were given to you as a tool in helping you make your evaluation. Also, for each problem that you list, indicate how confident you are that the guideline was violated and your opinion on how critical this violation is to the interface. Use a 1 (least confident, or critical) to 5 (most confident, or critical) scale.

You have as much time as needed to evaluate each task unit. Note however that the actions you perform allow you to traverse through the prototype only in the sequence given in this scenario. Therefore, take as much time as you need to evaluate the display or the results of your actions before performing your next action. Once you have finished, please inform the experimenter before going on to the next task unit.

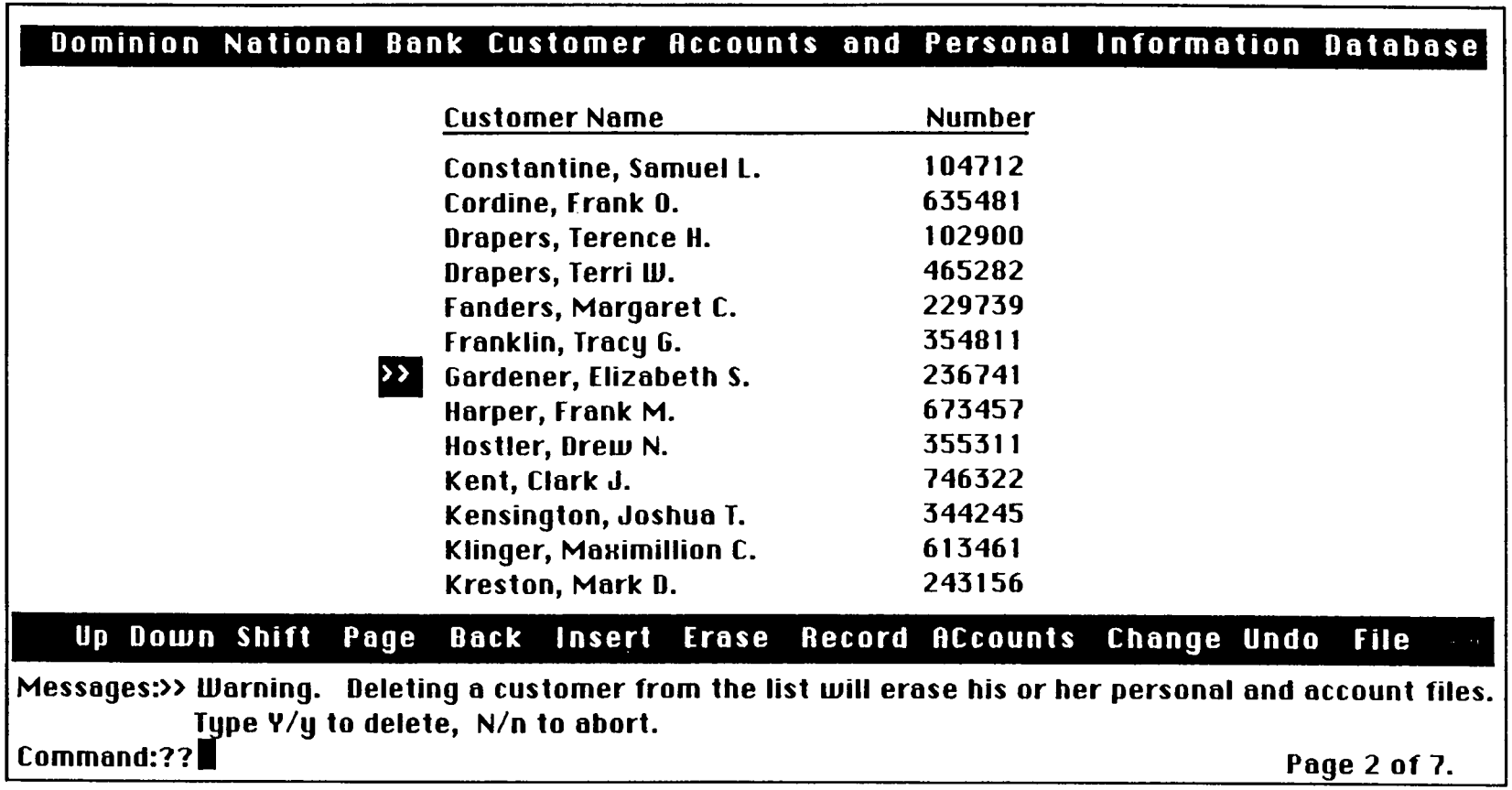
Unit A1:

Please remember to use the guidelines set that you were given as a tool in your evaluation. Also, please remember to verbalize as you evaluate the interface.

> Welcome to the Dominion National Bank Customer Accounts database. As a customer accounts manager, you will use the database to keep a complete and up-to-date listing of all customer transactions, checking and savings accounts, and loans.
>
> You are in the main window of the Dominion National Bank Customer Accounts database. You wish to delete a customer named Elizabeth Gardener from the database. Type the sequence of "b" and RETURN in the command entry line. Read the message screened in the message line.
>
> Since you really wanted to page down, type "p" and RETURN.
>
> Elizabeth Gardener should be the 7th name on the screen. To move down to her name, type "d6" and RETURN.
>
> Type "e" and RETURN to erase her name from the database. Read the prompt in the message line.

Before advancing to the next unit, again examine the display carefully and review the actions that you have performed. If you feel that a USI design guideline was violated in the interface, please record it on the form provided and indicate your confidence and the criticality of the violation. Remember that from 0 to 10 guidelines may be violated in this task unit. Once you have finished, please inform the experimenter before going on to the next task unit.

Insert Panel 2.1 Here



Panel 2.1 First snapshot from the instruction set of Prototype 2

Unit A2:

Please remember to use the guidelines set that you were given as a tool in your evaluation.
Also, please remember to verbalize as you evaluate the interface.

A confirmation prompt will be displayed. Respond to the prompt by typing "y" and RETURN .

You wish to obtain assistance on how to open and use the personal information window. To access help information, press PF1 key followed by the "h" and then PF1 key. The help window with a list of commands will be shown.

Use the sequence "p" and RETURN to page down until the entry "Record" is shown on the window.

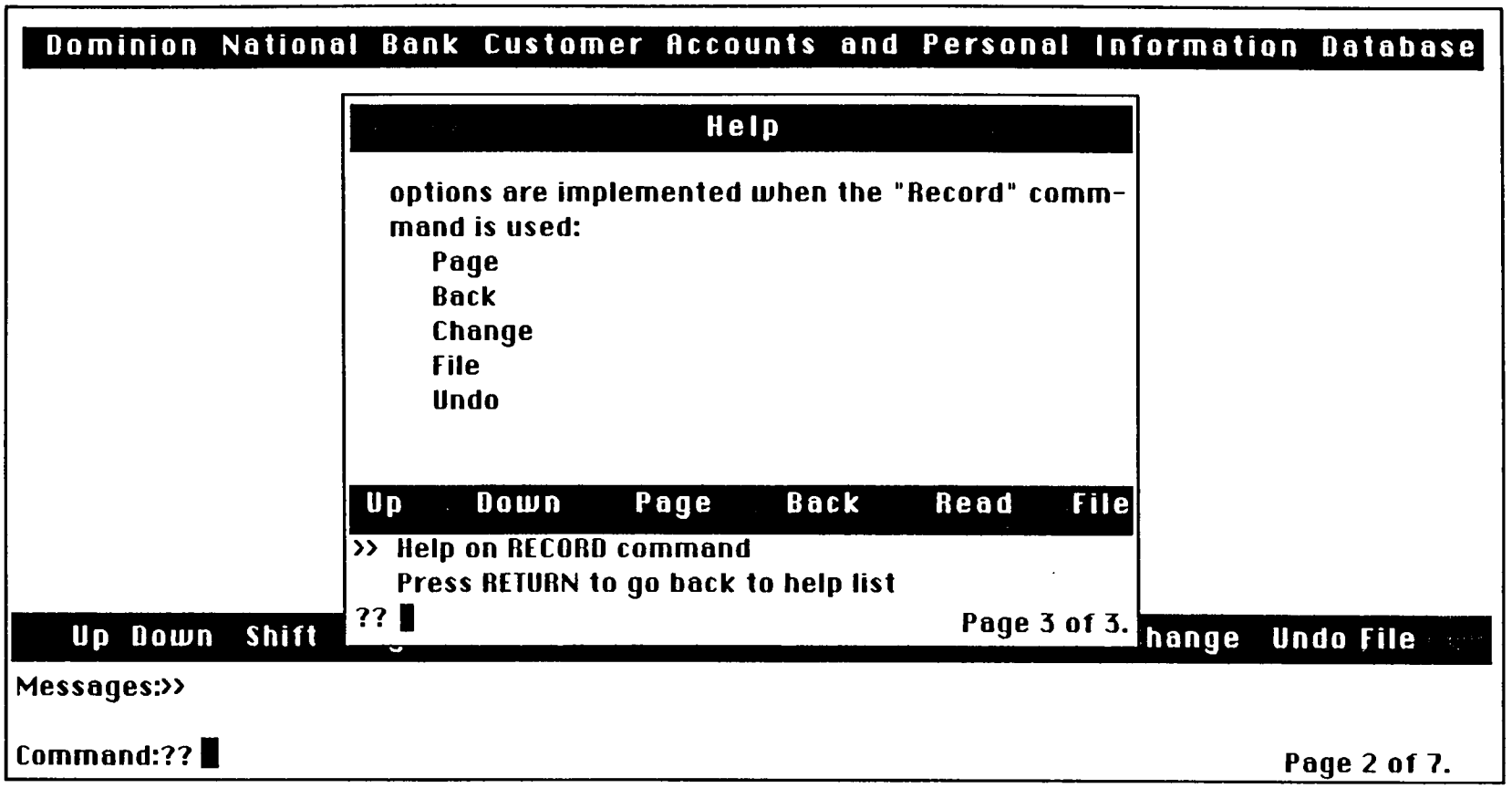
Scroll down the list to the "Record" entry by using the "d2" and RETURN command.

Press "r" and RETURN to read the help information on the entry "Record." The list will be replaced by text.

Page through the displayed information by pressing "p" and RETURN. Read through the complete help information on "Record".

Before advancing to the next unit, again examine the display carefully and review the actions that you have performed. If you feel that a USI design guideline was violated in the interface, please record it on the form provided and indicate your confidence and the criticality of the violation. Remember that from 0 to 10 guidelines may be violated in this task unit. Once you have finished, please inform the experimenter before going on to the next task unit.

Insert Panel 2.2 Here



Panel 2.2 Second snapshot from the instruction set of prototype 2

Unit A3:

Please remember to use the guidelines set that you were given as a tool in your evaluation.
Also, please remember to verbalize as you evaluate the interface.

Return to the main window by typing "f" and RETURN.

You wish to review a checking account for Maria Anderson. Page back through the customers list by using "b" and RETURN.

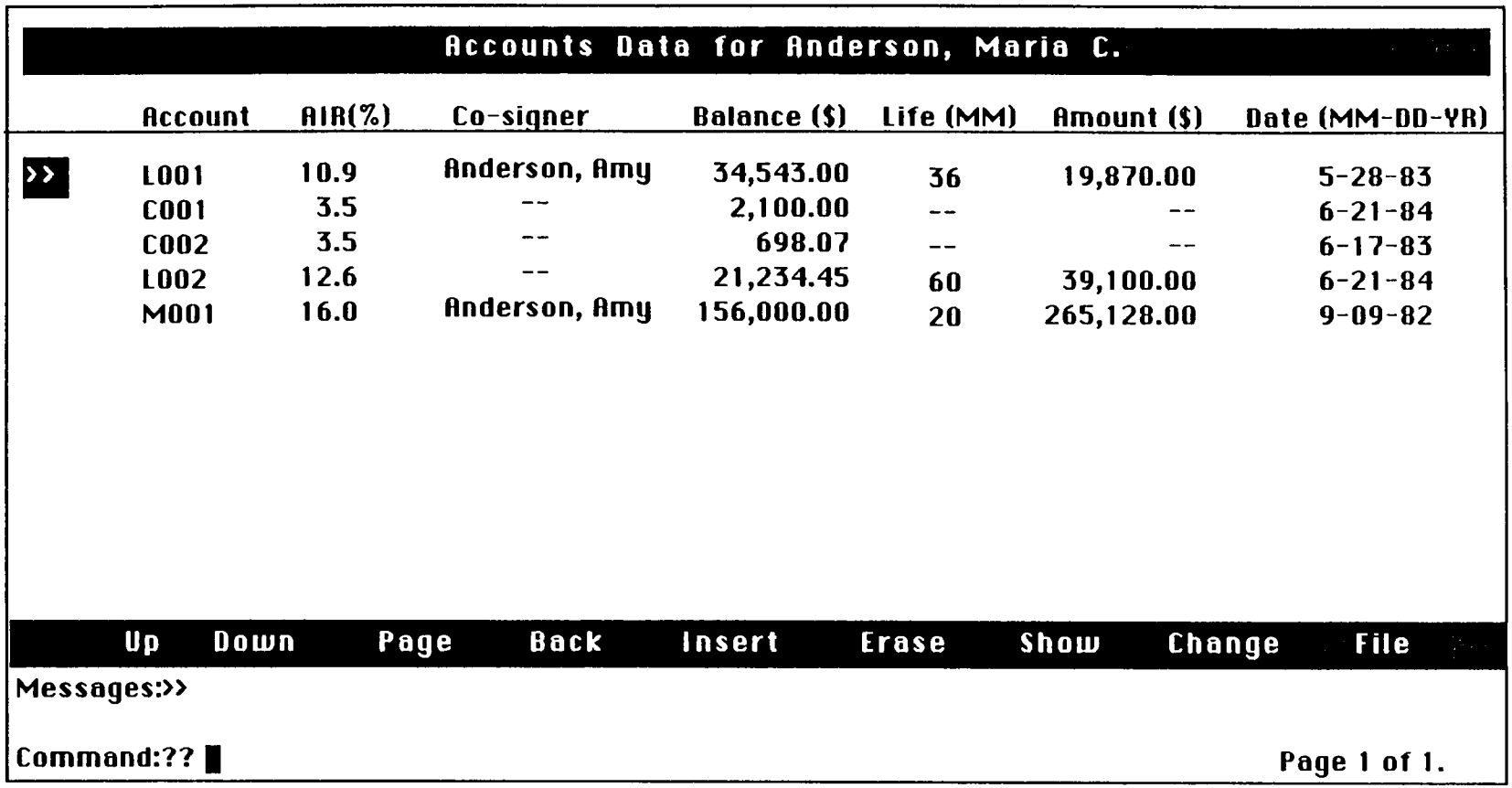
Maria Anderson's name will appear as the 5th entry in the displayed list of names. Scroll down to her name by typing "d4" and RETURN.

Type "a" and RETURN to open the accounts information window.

Once you have opened the account window, look up the annual interest rate for account L001.

Before advancing to the next unit, again examine the display carefully and review the actions that you have performed. If you feel that a USI design guideline was violated in the interface, please record it on the form provided and indicate your confidence and the criticality of the violation. Remember that from 0 to 10 guidelines may be violated in this task unit. Once you have finished, please inform the experimenter before going on to the next task unit.

Insert Panel 2.3 Here



Panel 2.3 Third snapshot from the instruction set of prototype 2.

Unit A4:

Please remember to use the guidelines set that you were given as a tool in your evaluation. Also, please remember to verbalize as you evaluate the interface.

Exit the Accounts window by typing "f" and RETURN.

You are now ready to read the personal information of Desi Arnnz. To move the marker down to Desi Arnnz, type "d" and RETURN.

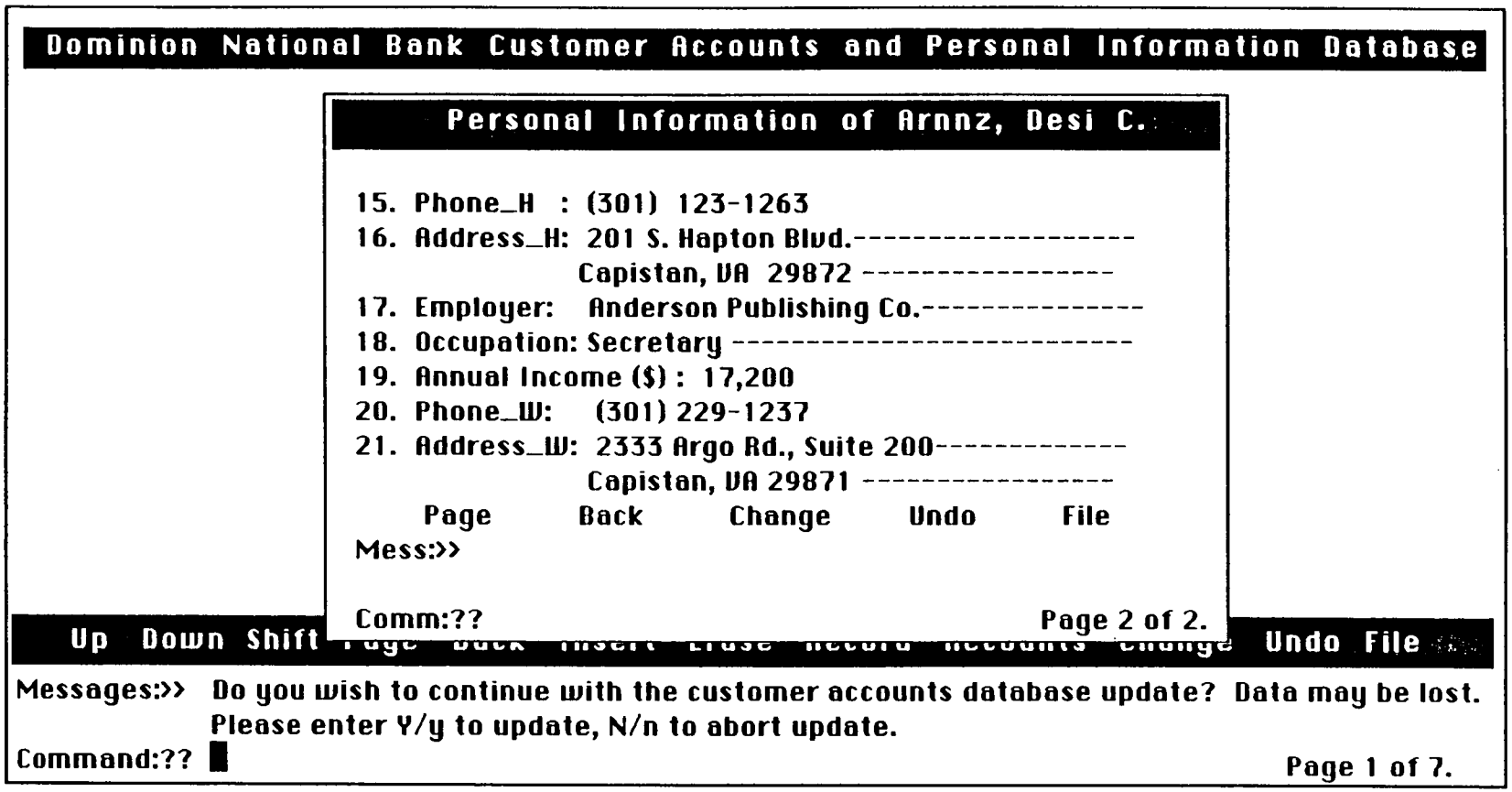
Type in "r" to open her personal information window.

Find the height and hair color of Desi Arnnz person.

After finding the height and hair color advance the personal information file by typing "p" and RETURN to page the file. Find her occupation.

Before advancing to the next unit, again examine the display carefully and review the actions that you have performed. If you feel that a USI design guideline was violated in the interface, please record it on the form provided and indicate your confidence and the criticality of the violation. Remember that from 0 to 10 guidelines may be violated in this task unit. Once you have finished, please inform the experimenter before going on to the next task unit.

Insert Panel 2.4 Here



Panel 2.4 Fourth snapshot from the instruction set of prototype 2

Unit A5:

Please remember to use the guidelines set that you were given as a tool in your evaluation. Also, please remember to verbalize as you evaluate the interface.

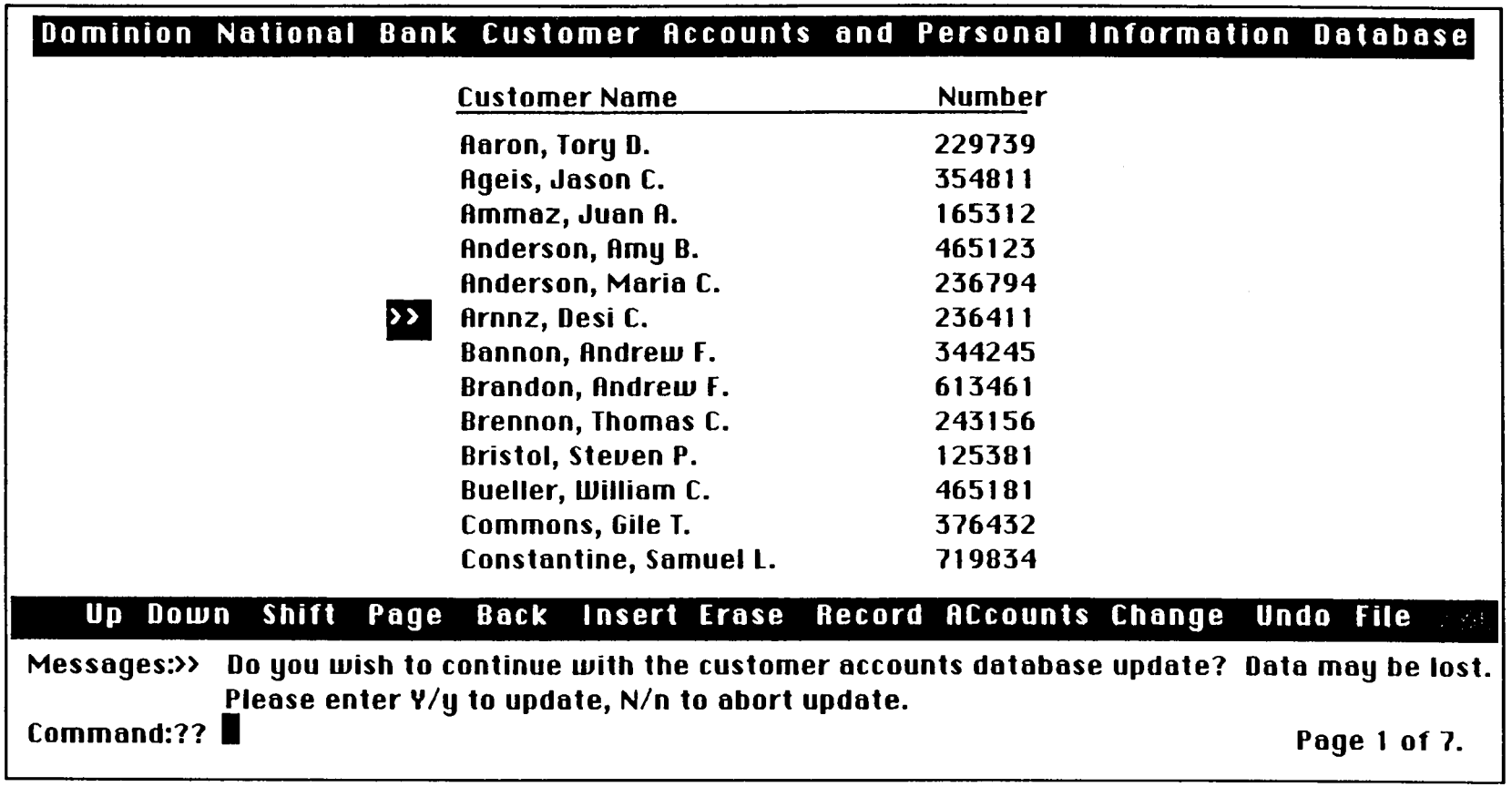
Return to the main window by typing "f" and RETURN.

Again type "f" and RETURN to quit this part of the experiment.

Read the prompt that is screened in the message field. Type in "y" and RETURN in response to the prompt.

Again examine the display carefully and review the actions that you have performed. If you feel that a USI design guideline was violated in the interface, please record it on the form provided and indicate your confidence and the criticality of the violation. Remember that from 0 to 10 guidelines may be violated in this task unit. Once you have completed this task, go see the experimenter for the next step in the experiment.

Insert Panel 2.5 Here



Panel 2.5 Fifth snapshot from the instruction set of prototype 2

APPENDIX D

Appendix D-1 Participant's Informed Consent Document

The following experiment is a study concerning the evaluation of user-system interfaces. During the experiment, you will be monitored with a close circuit video system. As a participant in this experiment, you have certain rights as explained below. The purpose of this document is to describe these rights and to obtain your written consent to participate in the experiment.

1. You have the right to discontinue participating in the study at any time, for any reason. If you decide to terminate the experiment, inform your researcher and he will pay you for the length of time you have participated.

2. You have the right to inspect your data and withdraw it from the experiment if you feel that you should for any reason. In general, data are processed and analyzed after a subject has completed the experiment. At that time, all identification information will be removed and the data treated with anonymity. Therefore, if you wish to withdraw your data, you must do so immediately after your participation is completed.

3. You have the right to be informed of the overall results of the experiment. If you wish to receive a synopsis of the results, include your address with your signature below. If after receiving the synopsis, you would like more indepth information, please contact Virginia Tech's Human Factors Laboratory and a full report will be made available to you.

This research is funded by a research contract between Virginia's Center for Innovative Technology and Computer Technology Associates. The researcher is Ray A. Reaux. He can be contacted at the following address and phone number:

Human Factors Laboratory
Room 302 Whittemore Hall
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061
(703) 961-4603

Further comments or questions can be addressed to the chairman of the Institutional Review Board for the Use of Human Subjects in Research. He or she can be contacted at the address and phone number listed below:

Office of Sponsored Programs
301 Burrus Hall
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061
(703) 961-5283

If you have any questions about the experiment or your rights as a participant, please do not hesitate to ask. The researcher will do his best to answer them, subject only to the constraint that he does not pre-bias the experimental results.

Your signature below indicates that you have read and understand your rights as a participant (as stated above), and that you consent to participate.

_____
Signature

_____

_____

_____
Printed name and address if you wish to receive a summary of the experimental results.

Appendix D-2 Questionnaire 1: Subject's History

Subject Name: _____ Subject Number: _____

How many years (including this year) of college have you had?

_____ 1 year
_____ 2 years
_____ 3 years
_____ 4 years
_____ 5 years
_____ 6 years
_____ more than 6 years

Have you ever used user-system interface design guidelines before?

_____ yes
_____ no

How much formal training have you had in user system interface design? For each course, please give the course number and the name of the professor.

	Course Number:	Professor:
_____ none		
_____ 1 course	_____	_____
_____ 2 to 3 courses	_____	_____
_____ 3 to 5 courses	_____	_____
_____ more than 5 courses	_____	_____
	_____	_____
	_____	_____

How many end-user interfaces have you been involved in designing?_____

For each of the interfaces that you were involved in designing, briefly describe the interface and indicate your level of involvement in person months:

_____
_____
_____
_____
_____
_____
_____

Appendix D-2 Questionnaire 1--continued

Subject Name: _____ Subject Number: _____

How many major software projects have you been involved in designing_____

Briefly describe each major software project that you were involved in designing and estimate the number of lines of code of the software.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Appendix D-3 Lookup Exercise 1

Subject Number: _____

Please answer these questions using the set of guidelines that you were given.

_____What is the page number corresponding to the second occurrence in the Table of Contents of the entry *Data Forms* ?.

_____Under what section in the Table of Contents is the first occurrence of the entry *Menu Selection* ?

_____In the index, how many pages are there for the entry of *distinctive format* under *Column heading* ?

_____If a person wanted to see the guidelines on *Blink Coding,* what page(s) would he or she go to?

_____What is the guideline number for the guideline titled *Conventional Assignment of Color Codes* ?

Appendix D-4 Lookup Exercise 2

_____Using the Table of Contents, locate the page number for the first occurence of the entry *Framing*.

_____Under what subsection of the Table of Contents can the second entry for*Tables* be found?

_____If you look in the Index at the the keyword *command* under the word *Abbreviation* , you will notice that there are two references (as indicated by the number 2 in parenthesis). What is the page number corresponding to the second reference.

_____What is the guideline number for the guideline titled *Alphanumeric Coding* ?

Appendix D-5 Evaluation Form

Subject Number:_____ Section Number:_____

User System Interface Problems--please use complete sentences:

_____
_____
_____
_____

Low confidence 1 2 3 4 5 High confidence
Low criticality 1 2 3 4 5 High criticality

_____
_____
_____
_____

Low confidence 1 2 3 4 5 High confidence
Low criticality 1 2 3 4 5 High criticality

_____
_____
_____
_____

Low confidence 1 2 3 4 5 High confidence
Low criticality 1 2 3 4 5 High criticality

_____
_____
_____
_____

Low confidence 1 2 3 4 5 High confidence
Low criticality 1 2 3 4 5 High criticality

Appendix D-6 Questionnaire 2: Guidelines Usability

Subject Number: _____

For each question, please circle one number that best conveys your response.

		Strongly disagree				Strongly agree
1.	I think that I would like to use these guidelines frequently in user-system interface design and evaluations	1	2	3	4	5
2.	I found the guidelines unnecessarily complex.	1	2	3	4	5
3.	I thought the guidelines were easy to use.	1	2	3	4	5
4.	I think that I would need the support of a human factors person to be able to use the guidelines.	1	2	3	4	5
5.	I thought that there was too much inconsistency in the guidelines.	1	2	3	4	5
6.	I think that most people could learn to use these guidelines quickly.	1	2	3	4	5
7.	I found the guidelines cumbersome to use.	1	2	3	4	5
8.	I felt confident using these guidelines.	1	2	3	4	5
9.	I found the examples helpful in understanding the guidelines.	1	2	3	4	5
10.	I think that there should be more examples.	1	2	3	4	5

Appendix D-6 Questionnaire 2--Continued

		Strongly disagree				Strongly agree
11.	I found the guidelines general enough to be used for a broad range of applications.	1	2	3	4	5
12.	I think that the guidelines are too general and should be more specific.	1	2	3	4	5
13.	I think that these guidelines could be an important tool for all phases of user system interface design.	1	2	3	4	5
14.	I think I would like the guidelines presented online rather than as a hardcopy manual.	1	2	3	4	5
15.	I think the guidelines are too qualitative.	1	2	3	4	5
16.	I think I would like the guidelines to be more quantitative (i.e. have hard specificnumbers attached to them).	1	2	3	4	5

APPENDIX E

Appendix E-1

Analysis of variance summary table for the 2^3 mixed factors design with the prototype evaluation time as the dependent variable.

Source	df	MS	F	P
Between Subjects				
Guideline Media (M)	1	3735,327.7813	3.22	0.0978
Order (O)	1	342,585.0312	0.30	0.5966
MxO	1	1,069.5313	0.00	0.9763
S/MO	12	13,907,993.3750		
Within Subject				
Abstraction (A)	1	323,409.0313	0.45	0.5133
AxM	1	220,614.0313	0.31	0.5882
AxO	1	262,993.7813	0.37	0.5548
AxMxO	1	516,890.2813	0.73	0.4111
AxS/MO	12	8,551,621.3750		
Total	31	27,862,504.2179		

Appendix E-2

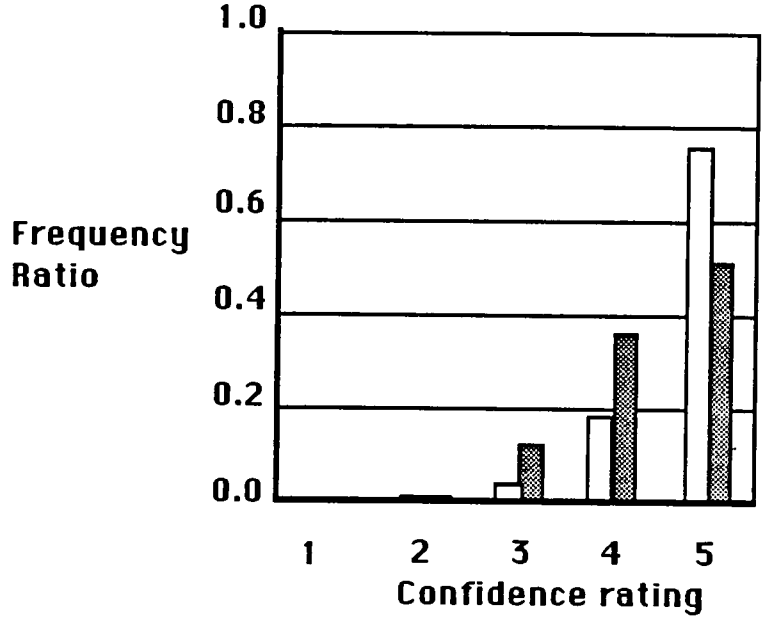
Analysis of variance summary table for the 2^3 mixed factors design with the ratio of index usage to guidelines usage time as the dependent variable.

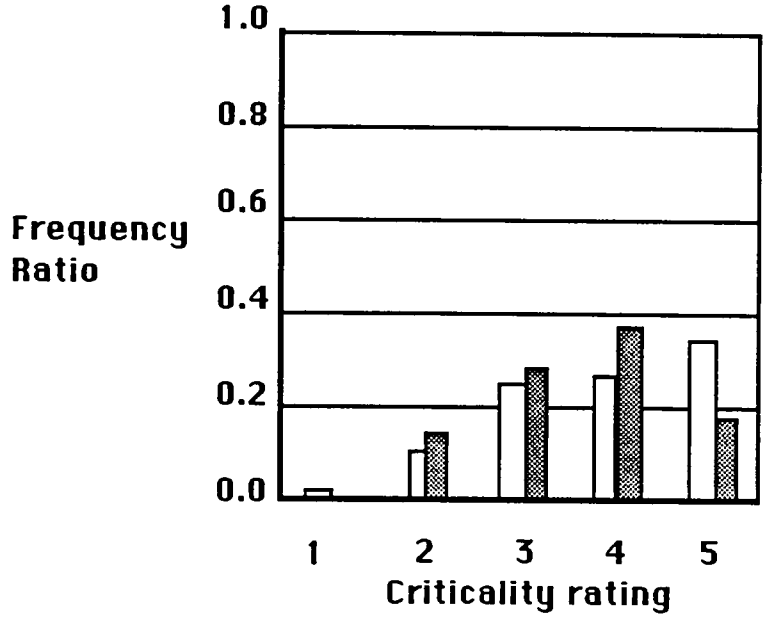
Source	df	MS	F	P
Between Subjects				
Guideline Media (M)	1	0.0125	1.25	0.2863
Order (O)	1	0.0377	3.76	0.0762
MxO	1	0.0000	0.00	0.9759
S/MO	12	0.1203		
Within Subject				
Abstraction (G)	1	0.0021	0.71	0.4160
AxM	1	0.0000	0.01	0.9155
AxO	1	0.0059	1.96	0.1864
AxMxO	1	0.0093	3.10	0.1038
AxS/MO	12	0.0360		
Total	31	0.2238		

Appendix E-3

Pearson correlations for violations detected by total evaluation time and guidelines usage time with guidelines presentation medium and levels of abstraction used as factors.

Source		Guideline	Evaluation
Levels of Abstraction			
Concrete	Pearson correlation	0.15813	0.30093
	Confidence	0.5586	0.2574
Abstract	Pearson correlation	0.18205	0.19653
	Confidence	0.4998	0.4657
Presentation media			
Hardcopy	Pearson correlation	0.13306	0.32669
	Confidence	0.6232	0.2168
Online	Pearson correlation	0.23821	0.37590
	Confidence	0.3743	0.1513

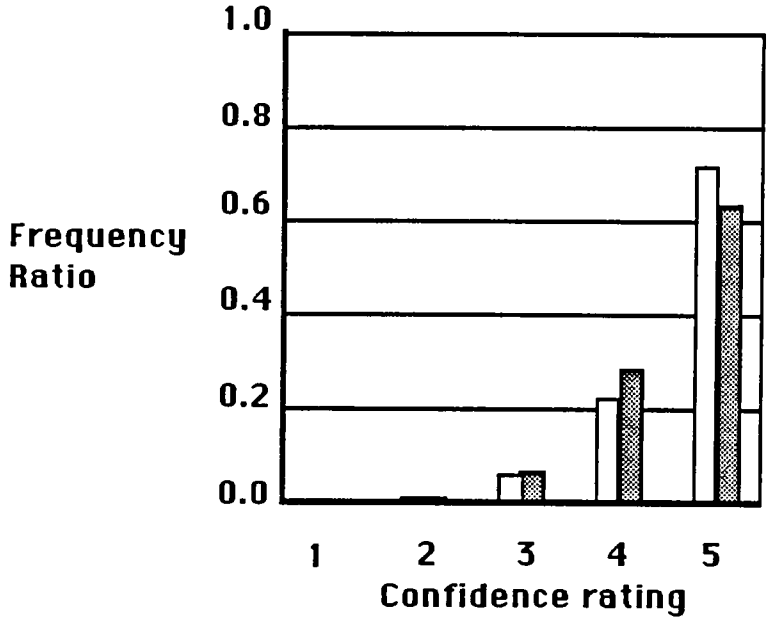


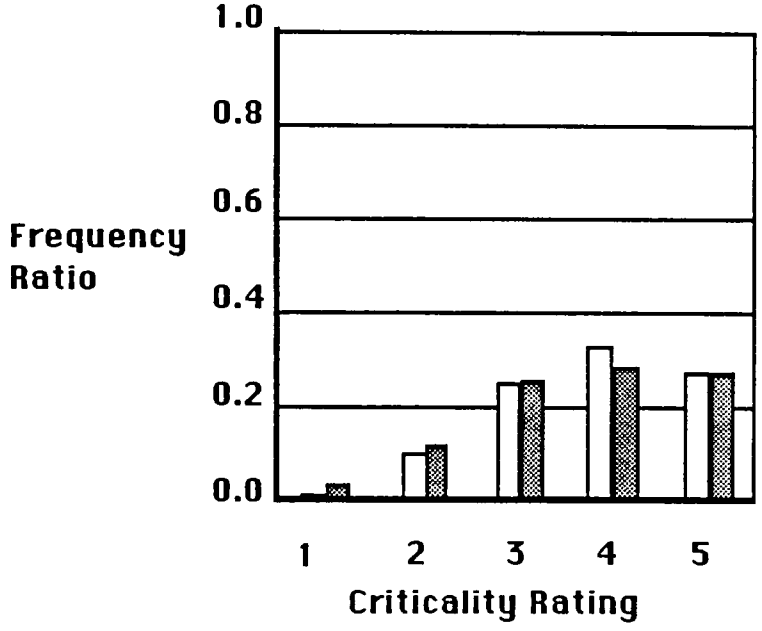


Prototype 1 violating concrete guidelines

Prototype 2 violating abstract guidelines

Appendix E-4 Frequency ratio distributions of subjective ratings of confidence and criticality for embedded violations found in each prototype.

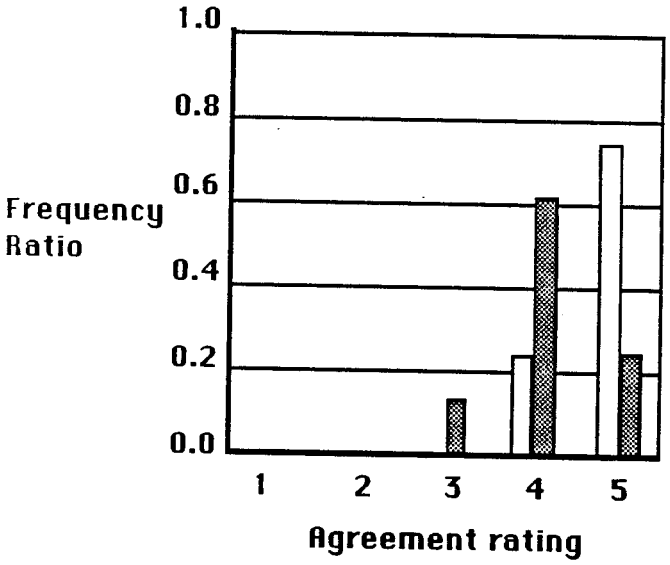




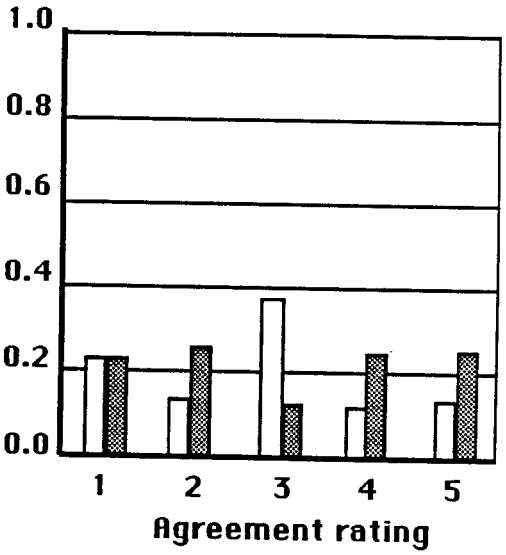
Guideline set presented in a hardcopy manual

Guideline set presented online

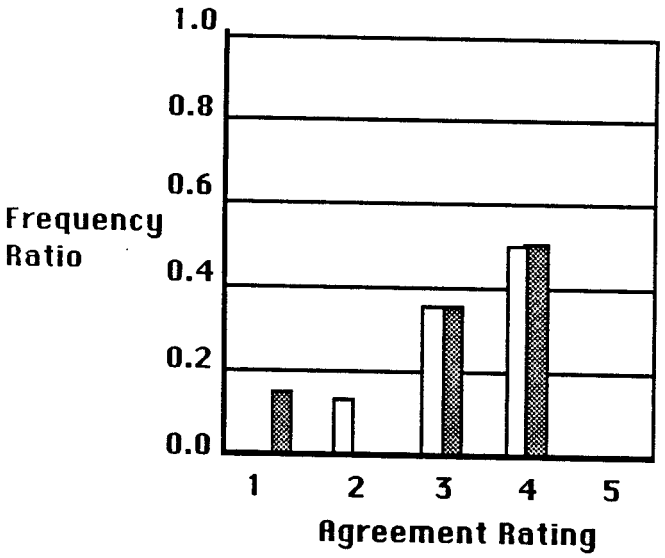
Appendix E-5 Frequency ratio distributions of subjective ratings of confidence and criticality for embedded violations found by groups differing in guideline set presentation medium..



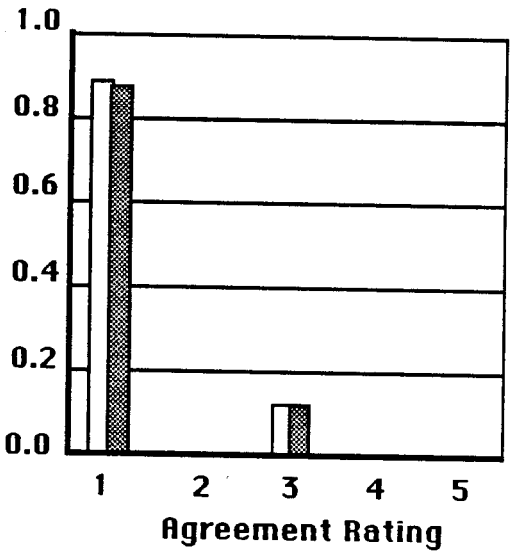
Q1: Would like to use these guidelines frequently in USI design and evaluation.



Q2: Guidelines are unnecessarily Complex



Q3: Guidelines were easy to use.



Q4: Support of a human factors person needed to use guidelines.

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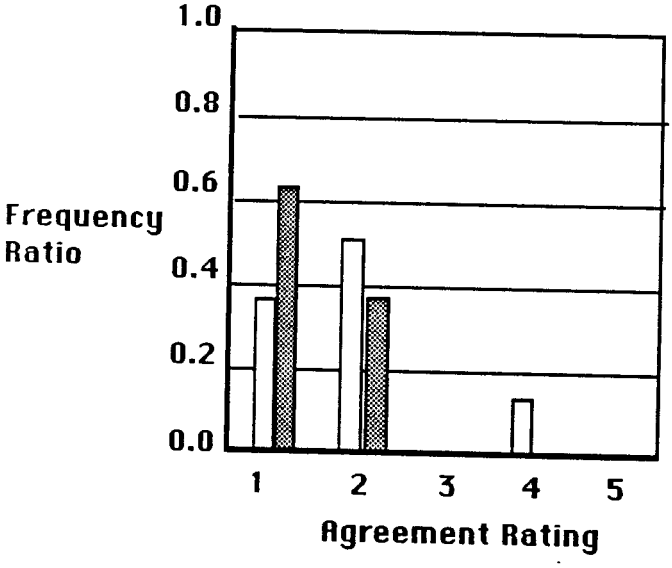
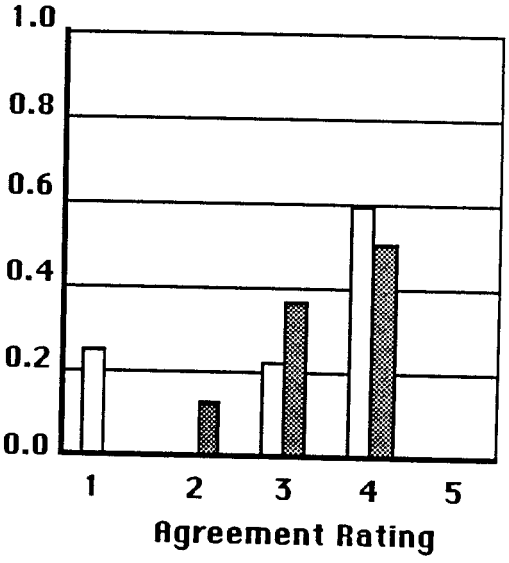
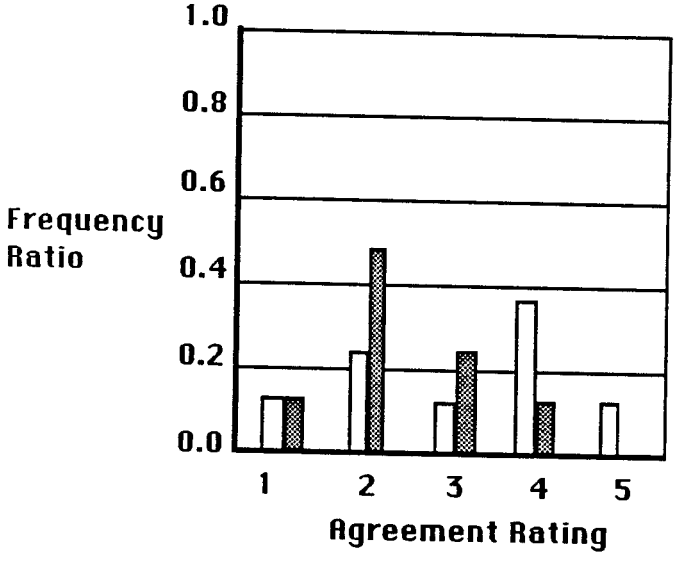
Appendix E-6 Frequency ratio distributions of responses to questions 1-4 of Questionnaire 2.



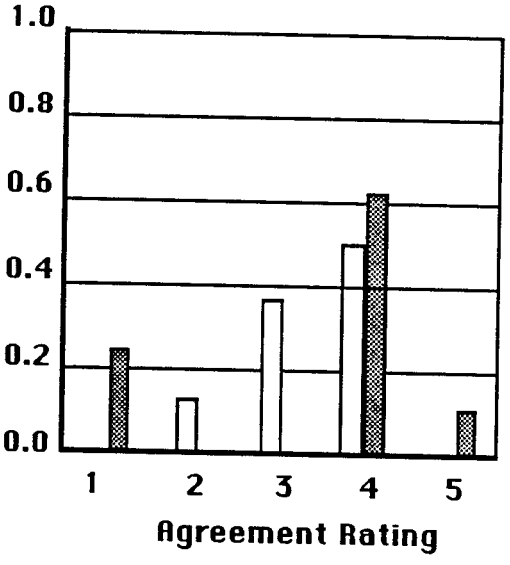
Q5 Too much inconsistency in the guidelines.



Q6 Most people could learn to use the guidelines quickly.



Q7 Guidelines were cumbersome to use.



Q8 Confidence in using guidelines.

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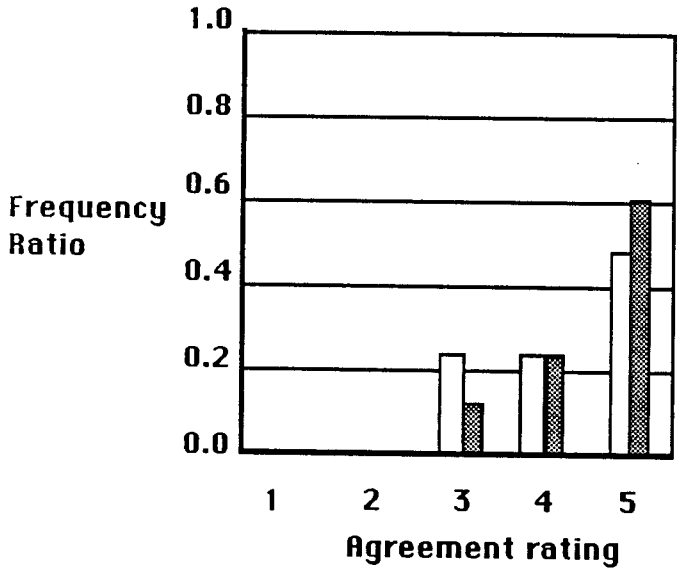
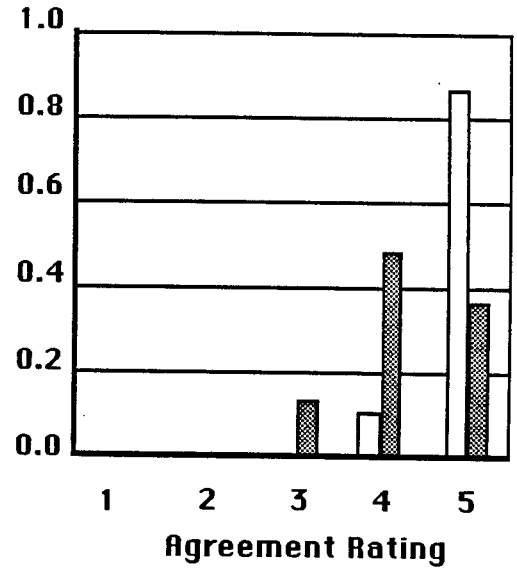
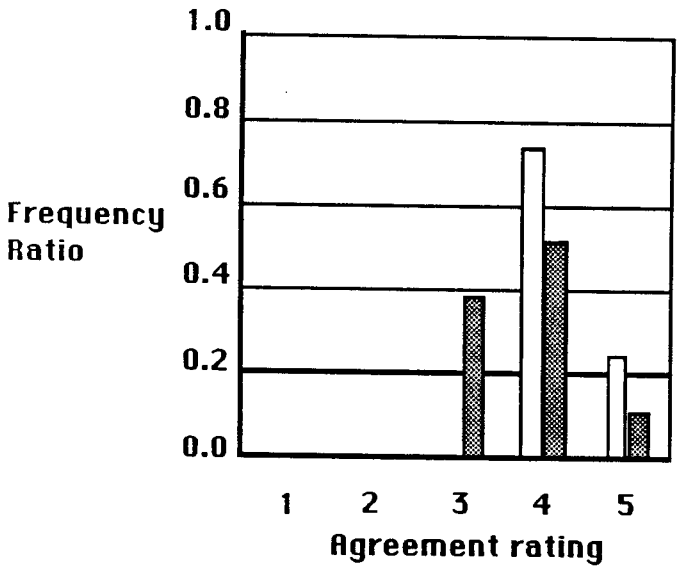
Appendix E-7 Frequency ratio distributions of responses to questions 5-8 of Questionnaire 2.



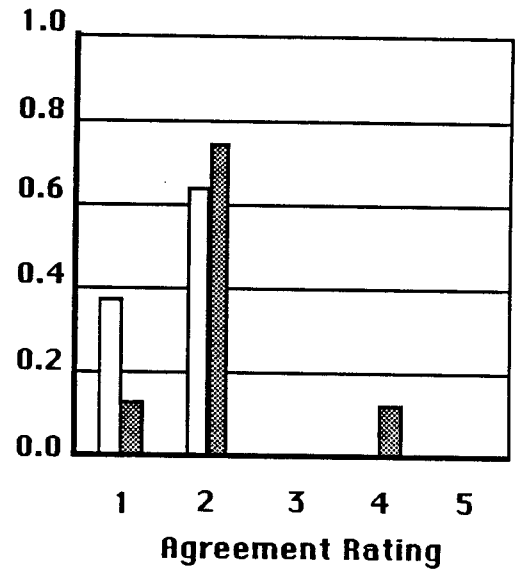
Q9 Examples were helpful in understanding guidelines.



Q10 More examples should be given.



Q11 Guidelines were general enough for a broad range of applications.



Q12 Guidelines are too general and should be more specific.

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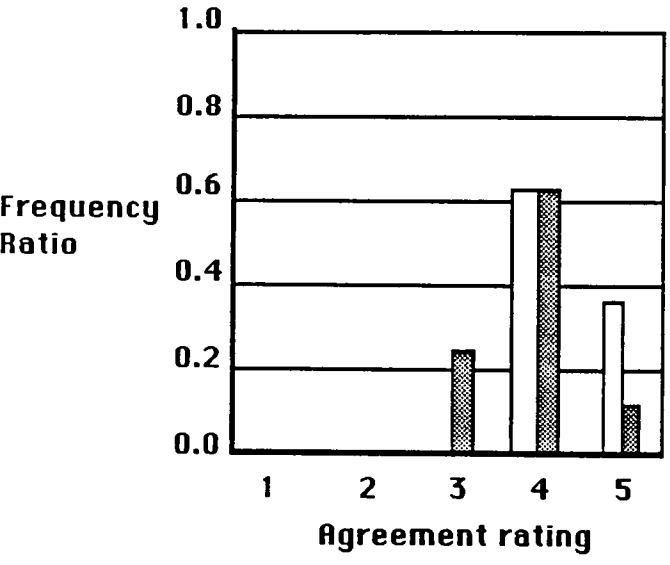
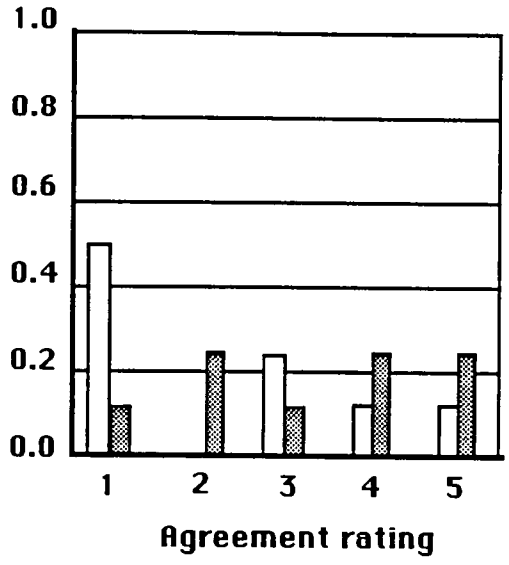
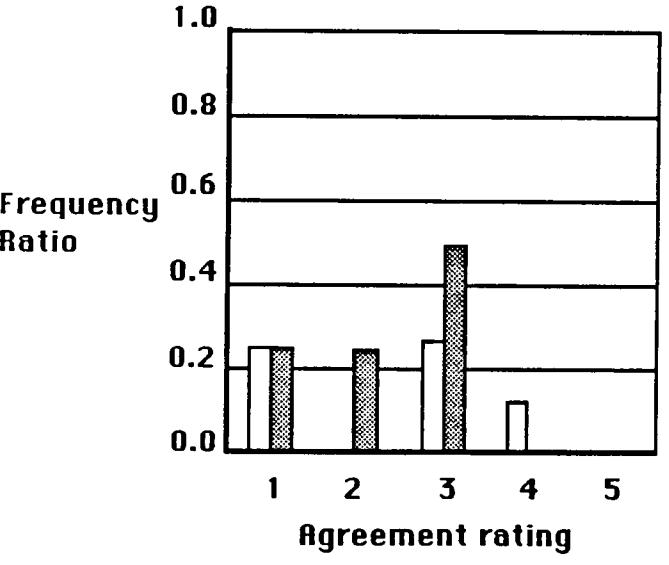
Appendix E-8 Frequency ratio distributions of responses to questions 9-12 of Questionnaire 2.



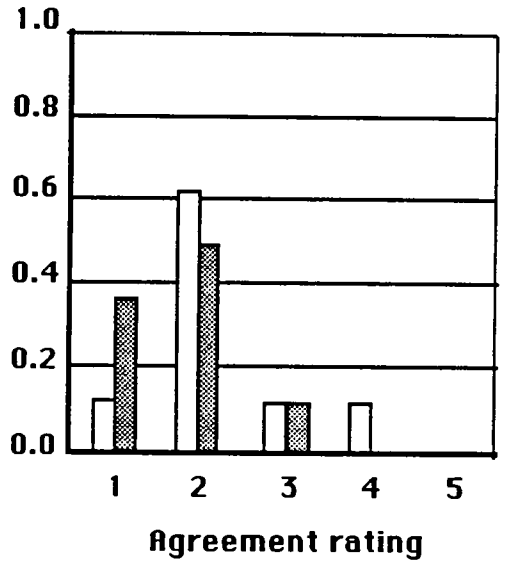
Q13 Guidelines could be important tool for all phases of USI design.



Q14 Would like guidelines online rather than hardcopy.



Q15 Guidelines are too qualitative.



Q16 Would like the guidelines to be more quantitative.

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Appendix E-9 Frequency ratio distributions for responses to questions 13-16 of Questionnaire 2.

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