ARMY RESEARCH LABORATORY

A Process Approach to Usability Testing for IMPRINT

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Abstract

Two sets of prototype screens for a complex, computerized analysis tool were evaluated using three usability analysis techniques. The experimental usability method identified more interface design problems of a severe nature than the other methods did and gave a clear indication of which prototype design to choose for the final development process. The implications for selecting appropriate usability techniques and using them collectively, as a process, are discussed.

CONTENTS

EXECUTIVE SUMMARY

The Hardware versus Manpower III (HARDMAN III) suite of personal computer (PC)-based analysis tools was developed to operate using an International Business Machines (IBM)-compatible machine with a 286 processor and the MicroSoft disk operating system (MS-DOS™). MS-DOS™ is a command-line, text-based operating system. Since the development of HARDMAN III, software companies have developed graphical user interfaces for use on IBM-compatible machines. To take advantage of the developments in software technology, the next version of HARDMAN III (which will be called Improved Performance Research Integration Tool [IMPRINT]) will incorporate the use of a graphical user interface under the Windows™ operating system. To facilitate an efficient transition of the DOS-based version of HARDMAN III to the Windows™ version of HARDMAN III (IMPRINT), a usability study was conducted on two computer prototypes that represented two graphical user interface designs for IMPRINT.

Three different usability analysis techniques were used to evaluate the two candidate interfaces for IMPRINT: an experimental evaluation, an individual heuristic evaluation, and a group walk-through evaluation. The experimental comparison of the two computer prototype designs was used to select a final design for development. The study incorporated a variety of usability analysis techniques in an experimental setting. Comparisons of these techniques were done to assess the overall effectiveness of each technique.

Results from the experimental analysis provided a clear indication of a difference between the two prototypes and therefore indicated a clear choice for final development. Results also indicated that task selection was a critical component for the experimental analysis technique. Results indicated that task times and error data were significantly different for the two separate sets of ten tasks.

The findings of this study also showed that different types of usability analysis techniques found different types of errors. It is therefore recommended that a series or group of usability analysis techniques be used for any interface design evaluation, instead of using a single evaluation technique.

USABILITY TESTING FOR THE IMPROVED PERFORMANCE RESEARCH INTEGRATION TOOL (IMPRINT)

INTRODUCTION

The comparison of usability methodologies has recently appeared in the literature. Most articles have emphasized the relative cost and effectiveness for each usability technique (Karat, Campbell, & Fiegel, 1992; Virzi, Sorce, & Herbert, 1993; Jeffries, Miller, Wharton, & Uyeda, 1991). Questions addressed by this research include "How effective is one particular usability technique instead of another?" "How much does one technique cost in comparison to other usability analysis techniques?" "Are the benefits of cost savings of a given method reduced by lack of problem identification?"

Comparisons of usability techniques are, however, sometimes difficult to interpret. Many methods are still only loosely defined. Overlaps across techniques are common. Within each technique, different interpretations of the methodologies to be used can vary. One study (Jeffries et al., 1991) used a heuristic evaluation differently than it was first described by Nielson in 1990. Jeffries et al. (1991) used 62 guidelines, whereas, Nielson used only 9. Another study (Virzi et al., 1993) used several "flavors" of the heuristic evaluation for comparative purposes. In one study (Karat et al., 1992), the researchers stated the differences between experimental testing and the walk-through sessions lay primarily in the amount of data that were collected and the amount of involvement that the subjects had with the experimenters. This was done to "test the resource requirements of [each] method."

To attempt to clarify any interpretations about the usability techniques typically used, descriptions of each technique and variations associated with it are provided in Table 1. First, we begin with the experimental technique. Using the experimental method, subjects are asked to perform tasks using a computer interface, and subjects' interactions with the interface are then recorded. Although many data collection metrics have been developed and used for the experimental technique, they all generally fall into two categories: time and errors. Subjects' interactions with the interface are almost always "task based" and not "free form." Subjects typically are not encouraged to make interface suggestions during the session.

The second usability analysis technique is the individual walk-through, or think-aloud technique. This procedure involves allowing a subject to interact with an interface, and the subject is encouraged to vocalize any problems encountered with the computer interface. This technique might also be a "task-based" interaction or it might be a more "free form" interaction in which no tasks are given. This method can sometimes be augmented with usability guideline information, which is given to the subject to help him or her identify problems. If usability guidelines are given, the technique is usually then referred to as a heuristic evaluation. Data collection is usually in the form of comments and suggestions and not in the "time and errors" format that characterizes the experimental usability techniques. Participants can vary in experience; however, Desurvive, Lawrence, and Atwood (1991) and Nielson (1992) have shown that for a heuristic evaluation, human factors professionals give better results than non-human factors evaluators.

Table 1

Characteristics of Usability Techniques

	Type of interaction	Data collection	Usability guidelines	Usability experience
Experimental	Task	Both	Not given	Mixture
Individual				
Heuristic	Usually free form	Subjective	Given	Human factors
Walk-through	Task or free form	Subjective	Not given	Mixture
Group				
Pluralistic	Task or free form	Subjective	Usually not given	Wide mixture
Walk-through	Task or free form	Subjective	Usually not given	Mixture

The final usability technique is a group evaluation in which evaluators are brought together and encouraged to talk about interface problems that they identify collectively. This may be called a "cognitive walk-through" or, more recently, a faster paced version has been named a "cognitive jog through" (Rowley & Rhoades, 1992). Also the group may or may not be given a set of usability guidelines, and it may or may not be encouraged to work with the interface in a task-based scenario or in a more "free form" scenario. Participants' professional experience and background can vary. In fact, one researcher (Bias, 1991) proposes the pluralistic methodology which uses a group with the widest amount of experience possible.

Using this simple catagorization scheme for usability methods, a comparison of the cost and effectiveness of the various methods is easier but by no means completely clear. The desire to use one technique instead of another is driven by cost and effectiveness concerns. However, the literature is unclear which variant of which technique (experimental, individual or group walk-throughs) is the "best."

Karat et al. (1992) found that in comparison to the individual and group walk-throughs, the experimental method identified the largest number of problems and identified problems missed by the other two techniques. Cost analysis also showed that the experimental usability technique used the same or less time to identify each problem. As mentioned previously, the experimental and individual walk-throughs differed only in the amount of data collected and the amount of involvement the subjects had with the experimenters.

Contrary to the findings of Karat et al. (1992), Jeffries et al. (1991) reported that heuristic evaluations found the most problems with the lowest cost. However, Jefferies used user interface (UI) specialists who were "members of a research group in human-computer interaction, [and] had backgrounds in behavioral science as well as experience providing usability feedback to product groups." In contrast, Karat used "predominantly end users and developers of graphic user interface (GUI) systems, along with a few UI specialists and software support staff."

In another study, Virzi et al. (1993) found that of three usability techniques (heuristic, think-aloud [or individual walk-through], and experimental), each was "roughly equivalent in their ability to detect a core set of usability problems on a per-evaluator basis. However, the heuristic and think-aloud evaluations were generally more sensitive, uncovering a broader array of problems in the user interface." Again, as in the Jefferies (1991) study, the "heuristic evaluation [was] conducted by in-house usability experts." Thus, taken altogether, an understanding of the cost-effectiveness of each method must include, not only an understanding of the method, but also of the subjects or evaluators, the type of information yielded by the method, and the actual resources involved using the method.

OBJECTIVES

The goal of this study was twofold: One, the selection of one of two different interface design prototypes for a fairly complex analysis tool and the continued refinement of the selected design. Two, to compare usability analysis techniques, with an emphasis on using the techniques in a sequence as a continuing process. Techniques were selected to cover the range of currently employed techniques and a comparison was done to confirm any perceived strengths or weaknesses. The three usability methods were (1) an experimental evaluation, (2) an individual heuristic walk-through with usability guidelines, and (3) group walk-through.

SUBJECTS

Twenty subjects participated in the experimental evaluation, all of whom were employees of the U.S. Army Research Laboratory (ARL). Of those 20 subjects, 10 participated in the heuristic evaluation and 10 participated in the group walk-through evaluation. The subjects had various educational and professional backgrounds, but all these subjects were equal in experience with the tasks to be performed with the software. They had each received a 3-day training course on the predecessor DOS-based software Hardware versus Manpower (HARDMAN III) but had not used the software since the course.

MATERIALS AND EQUIPMENT

We developed our process and conducted our usability evaluations during the design of the U.S Army computer program entitled IMPRINT. Two IMPRINT prototypes were developed. The program was designed to run under the Windows™ operating system. Prototyping of the program was done using the ToolBook™ development environment, which also runs under the Windows™ operating system. IMPRINT is the Windows™ version of a DOS™ program originally named HARDMAN III. Thus, HARDMAN III provided much of the groundwork for the conceptual design of IMPRINT. HARDMAN III is a very complex task network sequencing program, and consequently, the two IMPRINT prototypes were very complex as well. Both prototypes mimicked the functionality of the final program. The interactive prototype we developed was either used directly on a computer or was displayed on a large screen television. Twenty subjects were each tested individually using the same GateWay 2000 33-MHz computer with a color video graphics array (VGA) monitor. Data during the experimental section were collected by use of a video camera and by the computer the subjects were using during the experiment. The computer recorded when each task started and when each task was completed, as well as each mouse click in between the start and end times.

PROCEDURE

The interactive screen prototypes were presented in a counterbalanced scheme so that the time and errors for each could be compared. Although all subjects had received a HARDMAN III training class some months before the experimentation, they received refresher training immediately before the experiment. Subjects had to successfully complete five training tasks before proceeding with the experiment. The experiment consisted of two sets of ten tasks that would be performed using the software. (Ten subjects received one set of ten tasks; ten subjects received the other set of ten tasks.) The set of ten tasks was presented in a different random order for each subject. Subjects were not told to work as fast as they could or to make as few errors as they could. They were told that they were being recorded by the computer and to complete each task to the best of their ability.

The heuristic evaluation was conducted immediately after the experimental section. Of the 20 subjects who participated in the experimental evaluation, 10 were randomly selected for the heuristic evaluation and given the set of usability guidelines shown in Table 2 (Nielsen & Molich, 1990). Subjects were then instructed to use the guidelines to identify usability problems with each interface.

Table 2

Usability Guidelines

Simple and natural dialogue
Speak the user's language
Minimize user memory load
Be consistent
Provide feedback
Provide clearly marked exits
Provide shortcuts
Good error messages
Prevent errors

Subjects were told to take as much time as they needed. Subjects could choose to use the computer on-line versions of the prototypes or be given a printout of each screen from which to work. Many subjects wrote their comments directly onto the heuristic guideline sheet that was given to them.

Finally, the group walk-through technique used subjects who were the remaining ten from the previously conducted experimental evaluation. Subjects met in one room facing a large screen monitor displaying the prototype. One experimenter served as the moderator for the session. The session was "task based" in that the same tasks that were used previously for the experimental section were used again for the group walk-through. Task lists were given to each of the subjects, and then each task was presented for evaluation with the interface. Subjects vocalized any concerns they had with the interface while each task was being exercised. Data were collected by using a video camera and by a second experimenter taking notes during the entire session.

RESULTS

As Figure 1 illustrates, the experimental evaluation identified more problems than did the heuristic or group evaluation techniques. The experimental evaluation technique identified a total of 15 problems.

Severity ratings of each problem identified were calculated using a (high, medium, and low) three-point scale which was based on a subset of the Problem Severity Classification (PSC) ratings used by Karat et al. (1992). The subset we used was the impact of the usability problem on the end user's ability to complete the task. Two human factors experts conducted the severity ratings. Each human factors expert did his own rating independently; then the ratings were compared for differences. If there were any disagreements, discussion ensued until a consensus was reached. Figure 2 shows the severity rating scores for the problems found with each usability technique. As Figure 2 indicates, the experimental method identified the most number of high severity problems, a total of six.

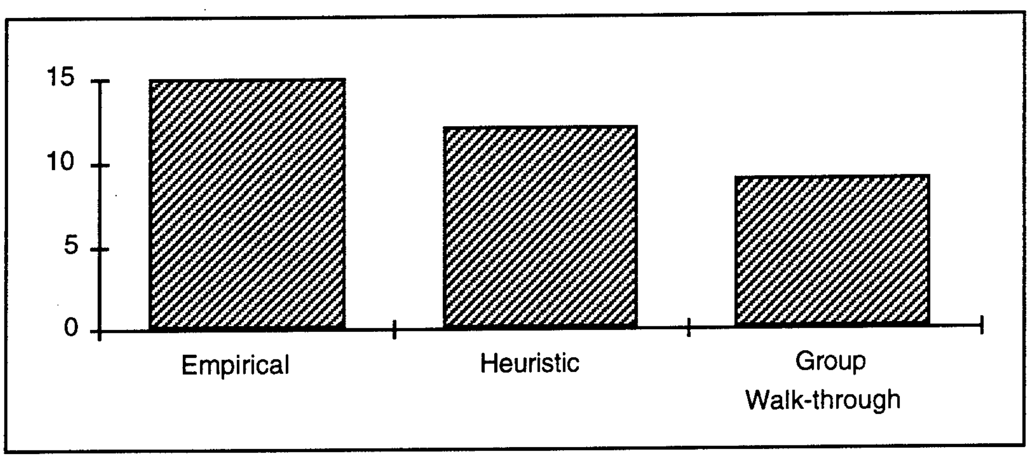

Figure 1. Number of problems identified.

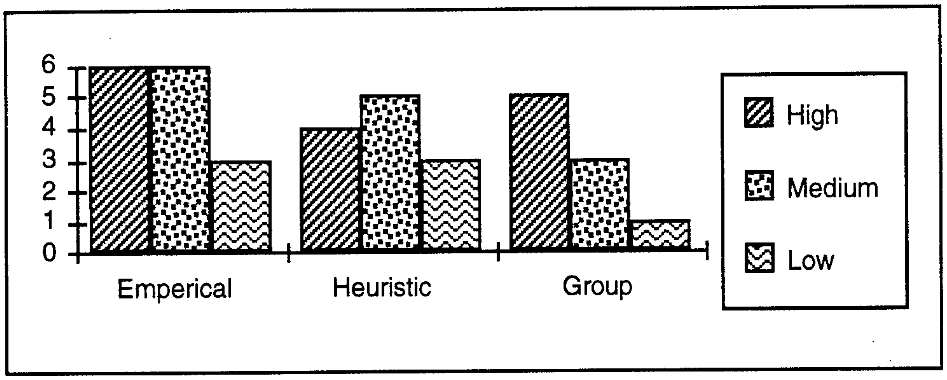

Figure 2. Problem severity identification.

Table 3

Results

	Prototype A	Prototype B
Task Set 1 Mean Task Time	78.66 seconds	114.83 seconds
Task Set 2 Mean Task Time	80.50 seconds	81.10 seconds
Task Set 1 Error Scores	3.91 substeps	7.49 substeps
Task Set 2 Error Scores	4.15 substeps	3.08 substeps

During the experimental evaluation, the two prototypes, here labeled Prototype A and Prototype B, were evaluated for the time and errors obtained with each prototype during the set of ten tasks. We found that for one group of ten tasks, Prototype A had significantly lower time and error scores than did Prototype B. However, for another group of ten tasks, time and error scores were not significantly different for each prototype. As shown in Table 3, the average task time for Prototype A was 78.66 seconds and for Prototype B was 114.83. However, for the second group of ten tasks, the average task time for Prototype A was 80.5 seconds and Prototype B was 81.1 seconds. An error score for each of the two prototypes was also calculated by taking the "ideal" or "perfect" number of sub steps and subtracting from the actual number of sub steps. For the first group of ten tasks, the error scores were 3.91 for Prototype A and 7.49 for prototype B. For the second group of ten tasks, error scores were 4.15 for Prototype A and 3.08 for Prototype B. A 2 (prototypes) x 10 (tasks) repeated measures analysis of variance (ANOVA) of the time data was conducted for both groups of the 10 subjects. Results for the first group indicated a significant main effect of prototype, $F(1,9) = 14.39, p < .01$, as well as task, $F(9,81) = 14.85, p < .01$. The effect of Prototype x Task interaction was also significant $F(9,81) = 5.15$ $p < .05$. The second group showed no main effect of prototype $F(9,81) = .42, p > .05$; however, they did show a significant effect of task type $F(9,81) = 5.70, p < .01$ as well as an effect of Prototype x Task interaction $F(9,81) = 3.31, p < .01$. The error data showed a significant main effect of prototype for both sets of ten tasks, $F(1,9) = 8.33$, $p <.01$ and $F(1,9) = 7.44, p < .05$, but no effect for task, $F(9,81) = 7.24, p > .05$, $F(1,9) = 5.03$ $p > .05$.

CONCLUSION

The usability analysis process should be a combination of usability analysis techniques, each of which has its own advantages and disadvantages. Together, however, each technique can complement the other methods and can collectively be more powerful than if used separately--in other words, a *Gestalt analysis*. For this study, one technique was not favored instead of another technique, but rather, all techniques were viewed as a *process*. This makes sense, since the very nature of computer interface design is in itself an extended process. Usability testing should not be looked at as a static, one-time expenditure, but instead, an evolving process. This process should encompass the best aspects of each technique.

We used the experimental method with the hopes of finding the most severe errors. As our results indicated, the most severe errors were identified by the experimental analysis technique. Also, because of the unique nature of the experimental method, it should be used in any evaluation process. Not only does it identify many severe errors, but as noted by Jeffries et al. (1991), also has the advantage of identifying errors that might never have been found by the other methodologies.

We would also like to point out that task selection is critical to an effective experimental evaluation. We found that different sets of tasks produced statistically different sets of results for time and error data. Task selection for experimental evaluations has been characterized as a problem similar to the content validity issue as described by Nunnally (Lewis, 1994; Nunnally, 1978). This area still warrants further research.

The experimental evaluation provided much of the information needed to satisfy our first goal, which was the selection of the best prototype design. Fortunately, for one group of ten tasks, there was a significant difference at the .05 level for time and error scores. Since the second group of ten tasks did not produce a significant difference in time and error scores at the .05 level for either prototype, the data for the first group of ten tasks gave us the best indication which was the better interface prototype design.

Next, the heuristic evaluation was given after the experimental section, in the hopes that subjects would draw from their experimental evaluation experiences and be more likely to give severe error inputs. Based on the data we collected, our assumptions were fairly accurate. Perhaps more importantly, it appeared that the technique of using an experimental followed by the heuristic evaluation produced fewer low priority errors.

The group heuristic walk-through evaluation also used the same subjects who had previously received the experimental evaluation, with the hopes that input would be based on the experience that the subjects had received during the experimental evaluations. However, because of logistical problems, the meeting was not held soon enough after the experimental evaluations, and subjects spent much of the evaluation session trying to remember what they had done during the experimental evaluations. The group evaluation did, however, produce a large number of severe errors, second only to the experimental method.

The idea of viewing computer interface usability testing as a *Gestalt analysis*, instead of a single technique or methodology, is an attractive one. The literature indicates that some techniques may be more effective than others in identifying certain types of problems and that each technique might complement the others in finding all types of usability problems. Further research needs to be done to help clarify this area as well as to identify the best order in which to use each methodology in an overall usability process.

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Two sets of prototype screens for a complex, computerized analysis tool were evaluated using three usability analysis techniques. The experimental usability method identified more interface design problems of a severe nature than the other methods did and gave a clear indication of which prototype design to choose for the final development process. The implications for selecting appropriate usability techniques and using them collectively, as a process, are discussed.

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