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A COMPARISON OF NOVICES' INITIAL PERFORMANCE, LEARNABILITY AND MEMORABILITY WITH A WEB-BASED IR INTERFACE

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ABSTRACT

This paper reports on an empirical study of novices' searching with a web-based IR interface. Two different novice groups took part in this study. The N_P group took part in the initial performance experiment. The N_{LM} group took part in two different tests. The first test measured their learnability with the interface after a brief "hands-on" training. The second test was run four weeks after the learning in order to assess their memorability of search skills. Novices' performance across all experiments was measured in terms of time taken to complete search tasks, search terms used, error rates, and success of the tasks performed. Their subjective satisfaction with the interface was also measured at the end of all tests. The results of the study showed that novices could readily perform simple search tasks. Novices' performance improved significantly when a brief "hands-on" training was provided. Their subjective satisfaction with the interface also improved after the training. However, novices' memorability of search skill was poor. Their satisfaction with the interface also diminished during memorability test. The paper concludes with some principles of effective IR interface design for naive searchers.

Keywords: Information retrieval; User learnability; User memorability; User interface satisfaction; Web-based information systems

INTRODUCTION

Use of information retrieval (IR) systems has traditionally been the domain of librarians and professional searchers. These systems have been used almost exclusively by such search experts for several reasons, such as the number of IR systems available, cost, and the complexity of interfaces requiring command languages. Since mid-1990s, several IR systems began web-based access to their databases which either replaced or coexisted with the earlier services. Today, almost all major IR systems have web-based access to their services. The fundamental characteristic of such web-based services is that they are inherently interactive and provide low cost and easier interfaces to a wide

variety of databases for direct end-user searching. Despite these changes and improvements, many recent studies reported that web-based IR interfaces are still difficult to use and learn for naive searchers (Borgman, 2000; Ahmed et al, 2004). The need for better web interface design that helps novices' initial searching, ready learnability and memorability of interface functionalities remains.

This paper reports on an empirical study on novices' searching with a web-based IR interface in three experimental conditions: initial performance, learnability of interface functionalities and their memorability of search skill after four weeks of learning. Two different naive groups took part in this study. The first group (N_P) took part in the initial performance experiment. The second group ($\boldsymbol{N_{LM}}$) took part in two different tests spaced four weeks apart. The first test measured their learnability with the interface after a brief "hands-on" training. The second test measured their memorability of search skills. Both naive groups also rated their subjective satisfaction with the interface at the end of all experiments.

PREVIOUS RESEARCH

A number of attempts to investigate novices' searching in various IR interfaces have been reported in the literature. Early studies reported that novices could perform simple searches with command interfaces (Lancaster, 1972; Fenichel, 1980; Vollaro and Hawkins, 1986). More recent studies reported similar results. Sullivan et al. (1990) found that novices could learn to do their own searches effectively using either command or menu interfaces. More recently, Ahmed et al. (2004) found that novices could perform simple search tasks in a web-based IR interface. All these studies also reported novices' problems with online searching. They tend to be slower, formulate simple queries, make frequent errors, and less successful when compared with experienced searchers. These results indicate the failure of IR interfaces to assist the naive searchers.

Several studies reported that age (Czaja et al. 1989; Mead and Fisk, 1998), gender (Sullivan et al. 1989), level of general computer experience (Mead et al. 2000), subject knowledge of the search topic (Allen, 1991; Vakkari et al., 2003), academic background (Borgman, 1996; Zhang and Chignell, 2001), and cognitive style (Palmquist and Kim, 2000) could affect novices' searching with IR systems. These studies also indicated that some of these differences are caused not only by the novices' individual characteristics and skills but also by the inadequacies of the interfaces. IR interface designs need to support novices with varying levels of experience and knowledge.

Many web-based IR systems offer a simplified version of their interfaces for effective use by naive searchers. Ahmed et al (2004) found that novices are significantly more satisfied with a web-based IR interface than experienced searchers. Novices' initial use of an IR system may have positively influenced their attitude with the interface. Davis (1989) argued that in the earliest stage of learning, novices' perceptions about ease of use may be formed both by the surface look of the interface, such as the use of icons and colours and by the result of "hands-on" experience with the interface. It would be interesting to see if novices' subjective satisfaction with an IR interface changes over an extended period of time.

The traditional IR evaluation studies focused primarily on recall and precision. IR interfaces are rarely evaluated with users. However, in order to evaluate IR systems, we have to understand the purpose for which these systems are intended. The user is an essential component of IR applications. It is, therefore, important to evaluate IR interfaces with real users to see if the usability is at the desired or required level. This study applied Nielsen's (1993) usability attributes to assess novices' initial performance, their learnability and memorability with a web-based IR interface.

METHODOLOGY

This study used the ISI Web of Science available at http://wos.mimas.ac.uk. Two different novice groups took part in the study. They were recruited from various departments at Loughborough University, UK. They all had no prior IR search experience, and had never attended any training programme on online searching. The N_P group (n=10) included six postgraduates, three research students, and one member of the research staff. There were five male and five female participants in the N_P group. The $\boldsymbol{N_{LM}}$ group (n=10) comprised six postgraduates, three research students, and one member of research staff. There were five male and five female participants in this group. All novices came one at a time for the experiments. They were asked to fill in a recruitment questionnaire which assessed their age, gender, and computer experience. At the beginning of each search session, novices were given a brief description of the purpose of the research and the experimental procedures that would be followed. Novices were told that if any task took more than twenty-minutes to complete, they would be stopped and asked to proceed to the next task. If they felt that they would be unable to complete a task and wanted to move on, this would also be allowed. The N_P participants were allowed to explore the interface for 15- minutes before performing the search tasks (Table 1). A similar methodology was followed for the $\boldsymbol{N_{LM}}$ group except that they took part in two tests spaced four weeks apart. In the first test (learnability), they were given a 15-minutes "hands-on" training to learn the basic

functionalities of the interface. These included a brief description about the use of icons, search options, Boolean operators, proximity and truncation. They also practised few searches on their own before performing the tasks. In the second test (memorability), held four weeks later, the same procedure was followed except that the training and practice were not repeated. The search tasks used in both tests were similar. Both N_P and $\boldsymbol{N_{LM}}$ participants completed a questionnaire on their satisfaction with the interface at the end of all tests. This questionnaire was based on QUIS (Chin et al, 1988).

Table 1: Search Tasks

Task 1:	Find information on the topic of computer-aided design
Task 2:	Find information about e-commerce
Task 3:	Find information on concurrent engineering in construction
Task 4:	Find information about applications of fibre optics
Task 5:	Find information about the works of Lawrence R Rabiner
Task 6:	Find work produced by the researchers in the Chemical Engineering department at UMIST
Task 7:	Find articles citing work by M. Smith published in the journal of *Addictive Behaviors*

Data collection

This study used a combination of data collection methods. These included transaction logs, computer screen recordings, and questionnaires. The transaction logs were obtained from MIMAS at the University of Manchester, UK. Data recorded through transaction logs included: database used, interface used (Easy Search or Full Search), search terms used, and system response (number of hits, error message, etc.). Lotus ScreenCam was used to record novices' screen activities. After capturing screen recordings, they were analysed and compared with transaction logs. At the end of all experiments, novices completed a questionnaire about their satisfaction with the interface. The data gathered for all three experiments were analysed according to the following performance and satisfaction measurement criteria.

(a) Performance data:

- *Time taken:* The total time taken to complete each search task. These times were extracted from the transaction logs and the computer screen recordings.
- *Search terms used:* The number of different search terms used for each task was calculated from transaction logs.
- *Error rates:* Number of different errors made was tabulated from transaction logs and computer screen recordings.

- *Success score*: Successful completion of each search task, as well as requested termination, and termination as a result of the twenty-minute time limit was counted from screen recordings.

(b) Subjective satisfaction

The QUIS measured novices' subjective satisfaction with the interface on a 7-point scale. The questionnaire covered items on overall reaction, screen, terminology and system feedback, learnability, and system capabilities.

RESULTS OF THE STUDY

Performance results

Table 2 shows the overall performance data for both N_P and $\boldsymbol{N_{LM}}$ groups. For time taken to complete tasks, means and standard deviations (in parenthesis) were calculated for each task. The time taken included both task completion time, instances of requested termination, and termination as a result of the twenty-minute time limit. It can be seen that the N_P group took longer time in completing search tasks than the $\boldsymbol{N_{LM}}$ group. $\boldsymbol{N_{LM}}$ group in both their learnability and memorability tests took nearly half of the time taken by the N_P participants. In terms of number different search terms used, the N_P group tried more query terms than the $\boldsymbol{N_{LM}}$ participants in their learnability and memorability tests.

Table 3 shows the average number of errors made in different search tests. The errors included errors in choosing appropriate databases and search terms, spelling errors, and errors in using Boolean and proximity operators. In general, the N_P participants made more errors in initial performance test than the $\boldsymbol{N_{LM}}$ group in both learnability and memorability tests. The success score for each task was 1 if the search task was successful or 0 if it unsuccessful. No partial credit was given. So, the maximum average success score for a task was 1, if all participants in a test were successful. Overall, $\boldsymbol{N_{LM}}$ participants were more successful in learnability experiment than their memorability and initial performance tests.

An independent sample *t*-test was carried out to see the difference between novices' initial performance and learnability in terms of time taken, search terms used, error rates and success score. The results of the test show that novices in the learnability experiment performed significantly better ($p<0.05$) across all performance measures than novices in the initial performance test. The same test between the initial performance and memorability tests showed a similar trend, although no significant difference was found in success score. A related sample *t*-test was carried out to see the

differences between novices' learnability and memorability tests. The results show that there were no significant differences in total time taken, search terms used and error rates by the N_{LM} group in learnability and memorability tests. However, there was a significant difference ($p<0.05$) in terms of success score.

An independent sample *t*-test for gender difference within the N_P group shows no significant difference between male and female novices in performance measures. The separate ANOVA results for age and general computer experience among N_P participants show no significant differences in performance. A two-way mixed model ANOVA was run individually for age, gender, and computer experience for the N_{LM} group. Novices' learnability and memorability were within subject factors, while age, gender, and computer experience were the between subject factors. The results showed that age difference was significant ($F=4.88$, $p<0.05$) for task completion time. The gender difference was not significant between male and female novices in the N_{LM} group. The success score was significant ($F=7.81$, $p<0.05$) among novices with different levels of general computer experience. The Duncan's test suggested that novices with 6-10 years and 3-5 years of general computer experience scored significantly better than novices with 1-2 years of computer experience.

Subjective satisfaction with the interface

The data collected through QUIS at the end of all tests are summarised in Table 3. The data suggest that novices are generally more satisfied with the interface in their learnability test than initial performance and memorability tests. The Mann-Whitney test results show that there was no significant difference in novices' subjective satisfaction between initial performance and learnability tests. The same test between initial performance and memorability shows similar results. The Wilcoxon test was carried out to look at the difference in novices' satisfaction between learnability and memorability. The results showed that memorability have lower values than learnability. The *Z* value is –2.01 which has a two-tailed probability of $p<0.05$. This suggests that the difference between learnability and memorability was significant at the 5% level.

DISCUSSIONS AND CONCLUSIONS

The main aim of this study was to find out if differences exist amongst novices' initial performance, learnability and memorability in searching a web-based IR system. It examined novices' initial performance, their learnability to operate the interface immediately following "hands-on" training and memorability of the interface functionality four week after their training.

Table 2: Novices Search Performance Across All Experiments

	Time taken (mins.)			*Search terms used*			*Error rates*			*Success score*		
	Initial performance	*Learnability*	*Memorability*	*Initial performance*	*Learnability*	*Memorability*	*Initial performance*	*Learnability*	*Memorability*	*Initial performance*	*Learnability*	*Memorability*
Task 1	6.20 (4.02)	2.90 (1.29)	2.90 (1.85)	1.90 (1.37)	1.30 (0.48)	1.30 (0.95)	0.20 (0.63)	0.20 (0.42)	0.20 (0.63)	0.90 (0.32)	1.00 (0.00)	1.00 (0.00)
Task 2	4.50 (5.34)	1.70 (0.95)	1.60 (0.84)	2.30 (2.21	1.00 (0.00)	1.20 (0.42)	0.10 (0.32)	0.00 (0.00)	0.30 (0.48)	1.00 (0.00)	1.00 (0.00)	0.90 (0.32)
Task 3	5.80 (6.16)	2.50 (1.35)	2.00 (0.94)	2.30 (1.34)	1.30 (0.48)	1.50 (0.53)	1.30 (0.67)	0.60 (0.70)	0.80 (0.63)	0.00 (0.00)	0.60 (0.52)	0.50 (0.53)
Task 4	4.90 (3.41)	2.20 (1.14)	2.00 (1.05)	2.80 (1.69)	1.70 (1.25)	2.00 (1.15)	0.90 (0.32)	0.60 (0.70)	0.70 (0.67)	0.20 (0.42)	0.60 (0.52)	0.60 (0.52)
Task 5	5.60 (3.37)	2.50 (1.58)	1.80 (0.92)	4.00 (1.49)	1.80 (1.14)	1.40 (0.70))	3.10 (1.73)	0.90 (0.99)	0.70 (0.82)	0.60 (0.52)	0.80 (0.42)	0.70 (0.48)
Task 6	8.30 (4.24)	7.30 (4.57)	7.80 (4.39	3.40 (1.26)	3.20 (1.14)	2.80 (1.55)	2.30 (1.57)	2.00 (1.33)	1.50 (0.97)	0.10 (0.32)	0.60 (0.52)	0.20 (0.42)
Task 7	8.60 (5.64)	4.70 (3.37)	3.50 (0.97)	3.20 (1.87)	2.20 (2.10	1.20 (0.42)	2.10 (2.33)	0.70 (1.89)	0.30 (0.48)	0.60 (0.52)	0.80 (0.42)	0.70 (0.48)
Overall	43.90 (17.63)	23.80 (9.46)	21.60 (6.62)	19.80 (5.87)	12.50 (3.66)	11.40 (1.71)	10.00 (4.29)	5.20 (3.97)	4.50 (1.51)	3.40 (1.51)	5.40 (2.07)	4.60 (1.78)

Table 3: Novices Subjective Satisfaction with the Interface

Question	*Initial performance*	*Learnability*	*Memorability*	*Question*	*Initial performance*	*Learnability*	*Memorability*
Overall reactions				***Terminology and system feedback***			
Terrible vs. wonderful	4.70 (0.82)	5.30 (0.48)	5.20 (0.92)	Simple and natural dialogue	4.80 (2.20)	4.90 (0.88)	4.90 (1.20)
Unimpressive vs. impressive	4.90 (0.99)	4.90 (1.10)	5.10 (0.88)	Terms used in the system	5.10 (1.60)	5.10 (0.57)	5.20 (1.14)
Difficult vs. Easy	4.70 (1.64)	5.40 (1.26)	5.10 (1.60)	Position of message	5.40 (1.58)	5.20 (0.92)	5.50 (0.71)
Inefficient vs. efficient	4.70 (1.42)	4.90 (0.99)	5.20 (1.48)	Prompts for input	4.30 (2.16)	4.70 (1.83)	4.90 (1.29)
Useless vs. useful	5.40 (1.58)	5.90 (1.10)	5.50 (1.08)	Inform about work progress	4.20 (1.75)	4.70 (1.57)	5.20 (1.03)
Unfriendly vs. friendly	4.60 (1.78)	5.30 (1.49)	4.50 (1.72)	Error messages	4.11 (2.09)	3.50 (1.72)	4.10 (0.74)
Frustrating vs. satisfying	4.90 (1.60)	5.60 (1.17)	4.80 (1.93)	***Learning***			
Ineffective vs. powerful	4.89 (1.54)	5.30 (0.95)	5.30 (1.05)	System learning	5.60 (1.35)	5.60 (1.51)	5.10 (1.91)
Dull vs. stimulating	4.70 (1.34)	4.40 (0.97)	4.50 (1.65)	Exploring by trial and error	5.40 (1.35)	4.60 (1.51)	4.30 (1.83)
Rigid vs. flexible	4.56 (1.51)	4.70 (1.34)	4.60 (1.58)	Remembering commands	5.33 (1.32)	4.90 (1.20)	4.20 (1.87)
Screen				Performing tasks is simple	4.67 (1.66)	5.40 (1.51)	4.90 (0.88)
Reading characters	5.60 (1.84)	5.90 (0.88)	4.90 (1.60)	Help messages on the screen	4.89 (1.45)	4.90 (1.29)	4.30 (0.95)
Onscreen information	4.50 (1.35)	5.00 (1.49)	5.20 (1.03)	Help access	5.11 (2.15)	4.44 (0.88)	4.40 (1.35)
Information arrangement	5.20 (1.32)	5.60 (0.84)	5.00 (1.05)	***System capabilities***			
Easy to find information	4.60 (1.65)	5.00 (0.82)	4.78 (1.48)	System speed	4.80 (1.75)	3.80 (1.75)	4.50 (1.58)
Screen sequencing	4.70 (1.89)	5.60 (0.84)	4.60 (1.35)	System reliability	5.11 (1.62)	4.90 (1.73)	4.10 (1.79)
Screen back track	4.60 (1.58)	4.20 (1.81)	3.90 (1.91)	Correcting mistakes	4.80 (1.14)	4.40 (0.84)	4.10 (1.45)
Back to main screen	5.40 (1.78)	5.33 (1.41)	5.89 (1.05)	Designed for all levels of users	4.44 (1.67)	4.30 (1.34)	4.20 (2.04)

The results of the initial performance showed that novices could readily perform simple searches. The learnability test showed that they could successfully learn to perform advanced searches when a brief "hands-on" training was provided. This result is consistent with earlier studies (Fenichel, 1980; Sullivan et al., 1990). Novices' memorability of search skills, however, weakened over time. The results showed a significant decrease in novices' success score in the memorability compared to their learnability test. Novices' subjective satisfaction with the interface also diminished significantly during the memorability test.

The key question arising from the results is why novices performed comparatively better in the learnability test than their initial performance and memorability tests. Assuming that training did contribute to their success, there are several possible explanations. The training was provided "hands-on" which is largely agreed as the best method of teaching computer applications. Most importantly, perhaps, the "one-to-one" training certainly boosted novices' confidence in online searching. In the learnability test, novices were trained in Boolean and proximity operators. Evidently the method had worked, as they were reasonably successful in using them in their learnability test. However, as time passed and the training became more distant, novices' success score declined significantly during the memorability test.

It was expected that novices would start with high error rates in initial performance and then the error rates might go down in their learnability and memorability. The training appeared to have stood the novices in good stead because most started their search with a low error rate. However, error rates did not fall off much in the memorability test. This suggests that novices' forgot from one test to another. Similarly, task time and search terms did not change much from learnability to memorability. Training appeared to have been useful for novices in learning online searches. Novices generally succeeded in constructing queries and getting results immediately after training, but it was evident that training was not enough to make them into successful searchers. Novices' success score in their initial performance, learnability and memorability suggest that the interface was not easy to use and remember.

The study of individual differences also provided some interesting results. Though there were no significant differences among novices in the N_P group, the N_{LM} group showed that the level of general computer experience and age influenced searching. Novices with higher levels of general computer experience were significantly more successful than novices with lower levels of computer experience. Younger novices performed better than older ones in time taken to complete the search tasks. This

finding is similar to other studies on the effect of individual differences on search performance. It is clear that novices through "hands-on" training become more proficient at manipulating the interface. As a result, they become more satisfied with the search interface in the learnability test. This finding is consistent with Davis (1989). However, novices' satisfaction rating with the interface declined sharply in the memorability as they forgot the interface functionality from one test to another. This study has showed that novices were able to perform simple searches readily. They were even able to learn effective online searches when a brief "hands-on" training was provided. However, rememberability of search skills between learnability and memorability was poor. Likewise, subjective satisfaction with the interface became lower in the memorability. These results suggest that the system did not help novices to use and remember the interface effectively.

Based on this study, some general principles for designing IR interfaces for naive searchers were suggested. These guidelines are not intended to be an exhaustive list of principles to follow when designing IR interfaces. Rather, they highlight some high-level concepts that should be considered in order to improve usability of IR interfaces.

1. *Strive for consistency*: It is important to make sure that layout, terminology, instructions, colour, fonts, etc. are used consistently across interfaces. IR interfaces also need to be consistent amongst themselves. Consistency across multiple interfaces could increase novices' learnability and memorability, leading to more effective searches and higher subjective satisfaction.
2. *Make the interface actions visible*: The query formulation process needs to be visible. Visual query formulation that allows users to select Boolean operators is useful. The search results should indicate whether or how Boolean operators have been used. The results should also display the terms included in a query.
3. *Assist users in refining the search query*: The designers could employ a number of techniques. First, they should provide clear and simple ways to modify a query, and the ability to reset the query statement. Second, the query can be summarised on the results page in a window on the top of the results list. This would allow the user to modify the query, thus reducing the need to navigate to search screens for query (re)formulation.
4. *Offer informative feedback*: The interface should indicate all aspects of the search process, such as the database(s), fields, what is being searched for, etc. When the search is complete, it should be obvious what happened and why. The information most important to users should be clearly displayed in the result pages. The inclusion of the query statement in the result and the highlighting of search terms are essential. These features help users to focus on their searches at

all stages of the search process. They guide the users not only in selecting which records might be of interest, but also whether the search resulted in the types of information desired.

5. *Offer simple error handling*: All error messages should be specific, constructive, uncritical, and should offer no more technical detail than necessary. The error messages should also indicate methods of diagnosing failures and provide hints on more successful search. The interface should always offer an easy way out from the system. This would encourage novices to perform exploratory learning since they could always try out new options, knowing they have the ability to get out of trouble without repercussions.
6. *Permit easy reversal of actions*: Every action should be reversible so users can go back to a previous state in a session. The users should be able to keep a history of queries and to return to search sets without re-keying the query. This would give users the flexibility to refine searches as they gain greater understanding of the topic being researched.
7. *Avoid complex navigation*: Reduce the amount of required navigation by making the functions available at all times. A navigation menu containing the different search options should always available while the users build the query.
8. *Reduce short-term memory load*: A number of techniques could be utilized in order to reduce short-term memory load. A compact design that minimizes scrolling and jumping is useful. Displaying search operators as options will allow users to select items through recognition rather than recall. The interface should describe the required format whenever users are asked to provide input, if possible, provide an example of legal input.

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