Application of Human-computer Interaction Theories to Information Design on Internet Portals

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(Abstract)

Internet portals are increasingly becoming a primary source of information. A portal is a gateway to information on the Internet or a hub from which users may locate relevant information (Strauss, 2000). Because university Web sites have various user classes, universities are beginning to adopt the portal concept for their Web sites.

The study conducted aimed to determine the effect of tailoring information content and presentation style on a university Web portal. User ratings of information design on three metrics and user task performance measures of time and errors were compared for four prototypes. Three prototypes were built on the basis of user requirements and two Human-computer Interaction (HCI) theories and one was a replica of an existing academic information portal. The three metrics were derived from the HCI theories.

The contributions of the study are a determination of user acceptance of and user performance with the tailored presentation styles and three metrics derived from HCI theories that can be used to compare alternative information presentation styles for portals. An important contribution is the remote data collection technique that was used in the study and a time-stamping technique that recorded clicks on hyperlinks.

DEDICATION

This thesis is dedicated to my grandfather Mr.G.Umanath Rao and my grandmother Mrs.G.Premalatha Rao

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CHAPTER 1. INTRODUCTION

1.1. OVERVIEW

The World Wide Web is a massive information warehouse whose store of information is growing in leaps and bounds. Today the average Internet user has access to around two hundred and seventy five million documents on the World Wide Web (Pirolli, 2000). Exploring this vast ocean of electronic information and finding relevant material is a daunting task for the user.

A microcosm of this expanse of information is the institutional information Web site. The Web site can be considered to be a software model of the institution itself and has a vast and varied store of content related to the institution. A university Web site falls under the category of institutional information Web sites. Today almost every university maintains a Web site in order to make its information accessible to a large and geographically distributed audience.

Several user-related issues are involved in the design of such a Web site, one of the key issues being ease of access, the ease with which information can be located and retrieved from the Web site. When faced with a broad spectrum of information categories and large quantities of information, the user will want to be able to navigate the site and find the required material with ease. A well-designed portal can make effective information retrieval possible.

An Internet portal is a starting point for several possible Web navigation paths and provides a consolidated view of all the information that can be reached from it. To cite a definition for a portal in general:
"It is an entry point or originating Web site for combining a fusion of content and information dissemination services, and attempting to provide a personalized 'home-base' for its users, from which they will be able to launch broad-based exploration 'expeditions' into cyberspace" (Davydov, 2001, p. 57).

There are several types of portals (See the Literature Review section). The type of portal used in the study is the institutional information portal. To cite a definition of an institutional information portal:
"It is a framework for the delivery of a consolidated, individualized presentation of the institutional Web" (Jacobson, 2000, p. 58).
Universities are beginning to adopt the portal concept in order to provide a consolidated view of the University Web site to its users. Using a portal in a University Web site can provide a convenient starting point to users for the Website navigation process. Some examples of universities that use Web portals are the University of California Los Angeles (MyUCLA), the University of Washington (MyUW) and the Virginia Polytechnic Institute and State University (Hokie Portal).

According to Jacobson (2000), the campus Web is a software model of the institution and its portals should provide varied views to cater to a diverse user population; they should serve as a multifaceted lens that provides a uniquely tailored view to each user class. By collecting disparate but related information from across the institutional Web and consolidating this information on a single page, institutions can construct an abridged version of the campus Web and this will facilitate quick and easy access to information most useful to each user class. From this it can be inferred that tailoring information to a specific user class can make it easier for the user to locate specific topics from the information displayed.

The study aimed to determine the effect of user-centered information presentation styles for a portal (tailored prototypes), which were built on the basis of theories of human-computer interaction. The study determined if the user–centered presentation styles have a significantly higher user acceptance rate than a presentation style that was not built with a user-centered approach.

The motivation for the study was the fact that higher education institutions are using their Web sites as a primary tool for information dissemination and so a user-centered design of the University Web site is of utmost importance. According to Dhillon (2001), knowledge management maximizes the benefits of shared information for an organization and helps the organization achieve its business objectives and so universities should organize relevant content on their Web sites so as to make them user-friendly information sources.

A related motivational aspect for tailoring information is that users who belong to different roles or classes and seek different information will find it difficult to find relevant information on a Web page that contains information for all user classes. According to Strauss (2000), universities will be challenged to build Web portals that provide user-specific information tailored to user requirements since they have users who belong to different classes with different requirements.

It is just as important to design Web portals so that the users find them easy to use. The above area of portal design is a potential avenue for research related to human-computer interaction. According to David Eisler,
"While it is easy to conceptualize the potential value of portals, to date there is limited published information available on student acceptance and use." (Eisler, 2000).

In the study, HCI theories were used to tailor information on the portal. The reason is that concrete principles and theories of human-computer interaction can be applied to the design of Web portals to ensure better ease of use. According to Pirolli (2000), greater theoretical understanding and the ability to predict the outcomes of alternative designs could facilitate more rapid evolutions of better designs. Pirolli (2000) also states that a designer armed with theoretical understanding could explore and explain the effects of different design decisions on World Wide Web designs before the heavy investment of resources for implementation and testing. Designers can then make more informed

choices between designs rather than randomly generating and testing design alternatives. They can decide which avenues are better to explore and which are better to ignore.

The study applied the following HCI theories to the user-centered presentation of information on a Web portal -- Information Foraging Theory and the concept of Information Scent. The above theory and concept are related to Web content design. A significant contribution of the study is a set of metrics developed by the author based on the theory and concept. Web portal designers can use the metrics to compare alternative information presentation styles for a Web portal. A portal that displays academic information categories on a university Web site was used for the study. The portal contained information that is relevant to undergraduate students. Three tailored prototypes were built and were named user-generated prototypes. One was in accordance with the Information Foraging theory, the second in accordance with Information Scent and the third prototype was tailored in accordance with both Information Foraging and Information Scent. Users performed tasks with the three tailored prototypes and one non-tailored or expert-generated prototype. User ratings and user task performance measures were recorded.

The academic portal that was used in the study is a generic university academic portal. The portal reflects the information design on most university academic information portals today. A team of university Web design experts designed the portal. On the portal the user can look through the listed information categories (labeled 'Main Categories') and choose a path to traverse in order to locate a required piece of academic information. The sentence or set of keywords next to each main category is an information cue (labeled 'Description'). Its purpose is to provide the user with a clear idea of the information contained in the main category it describes. The stronger the information cue the easier it is for the user to make a decision about his/her navigation path to find the required information (Theory of Information Scent).

The main categories of information displayed on the portal used in the study, and the descriptions accompanying them were decided upon by a team of Web design experts based on common knowledge of the university. The portal content is thus based on expert decisions and not user opinion. (B.C. Jones, personal communication, October, 2001).

The academic Web page selected for the study qualifies as a vertical portal in accordance with the definition " A vertical portal provides information on a single subject, closely related subjects, or information that is directed at a particular group of users" (Eisler, 2000). According to the definition, the academic portal falls under the category of a portal that provides information on closely related subjects that belong to the category of academics.

Figure 1. Information organization on an existing academic information portal

The study consisted of two parts -- Study 1 and Study 2. Study 1 was requirements gathering and Study 2 was testing of prototypes. During Study 1, requirements were collected from one of the user classes of the academic portal -- undergraduate students. The requirements pertained to the undergraduates' preference for academic information content and presentation on the portal. The study determined the effects of tailoring the information displayed on the academic portal according to user importance ranking, on the basis of the two HCI theories.

The requirements gathered during Study 1 were the basis for tailoring information to user preference and consequently for building tailored prototypes of the academic portal for undergraduates. The procedure used to gather requirements was based on the theories of Information Foraging and Information Scent (The Procedure Section contains details on the relevance of the theories to Study 1).

In Study 1 (requirements gathering), undergraduate students answered a questionnaire regarding a generic academic information portal (Figure 1). The students listed the main categories they consider relevant to them by assigning a rating to each. The participants rank-ordered the relevant categories according to priority. Similarly, they browsed a list of keywords associated with each main category, which was provided to them, and rated and rank-ordered them according to relevance to the main category.

The requirements were used to build three tailored prototypes for undergraduate students. One tailored prototype (called Main-category-Foraging) had the main categories arranged in order of user preference as indicated by the results of Study 1. In the second tailored prototype (called Description-Scent) the description accompanying each main category was a set of keywords that were rated as most relevant by the participants in Study 1. The third tailored prototype (called Both-Theories) was tailored with respect to both the above aspects (main categories and descriptions). A prototype of the existing information design was built for testing purposes and was referred to as the Control Interface, which was not tailored to user preference.

A set of forty undergraduate students (ten for each prototype) participated in a testing phase (Study 2) that involved performing information location tasks. The tasks were the same for all prototype users. After each task the participant rated ease of access (ease of finding information) and relevance of the descriptions to the target information they were asked to find. The rating was done on three metrics based on the theories of Information Foraging and Information Scent.

The data collected during Study 2 was analyzed according to a 2×2 factorial design (See Research Design Section). The user acceptance and performance measures for the four prototypes were compared to determine if tailoring the main categories or descriptions or both, had an effect on user acceptance or performance with the portals.

A contribution of the study is the set of three metrics based on HCI theories that were used to compare the existing and tailored information presentation styles for a Web portal. The remote data collection technique used in the study can be used by portal

information designers to collect user feedback and determine user acceptance and performance with the prototypes built by the designers. The process recommendations that emerged from the study can be used by university portal designers to tailor academic information on the portal according to user preference. A time-stamping technique that was developed as part of Study 2, recorded the computer system clock at the instant a participant clicked a hyperlink on the prototype. The technique is a valuable contribution of the study and can be used in remote usability evaluations and remote data collection procedures like the one carried out in the study.

1.2. LITERATURE REVIEW

The literature review for the study mainly consists of theories and concepts of human-computer interaction that can be applied to the user-centered design of Web portals. The theories discussed are Information Foraging Theory (Pirolli, 2000) and Information Scent (Chi, Pirolli, Chen and Pitkow, 2001). The theories were applied to the study as foundations on which process recommendations for tailoring portal content were based. Also, metrics derived from the theories can be used to compare alternative information presentation styles. Each theory is discussed and its application to the study is detailed. Also, the evolution and types of Web portals and the importance of user-centered design and participatory design are discussed. The relevance of each of the above topics to the study is enumerated.

1.2.1. Web portals

Portals originated as search engines, which are sites that help users locate relevant information on the Internet. As the amount of information available on the Internet increased rapidly, it became all the more difficult for users to navigate the Web and locate relevant information. Search engines were designed to make navigation easier in an attempt to reduce user frustration. Portals originated as search engines (Yahoo!, Lycos, Excite) and now they have evolved into central information location points for navigation of the Web (Davydov, 2001).

There are two broad categories of portals -- Horizontal and Vertical. Horizontal portals provide links to a broad spectrum of information across various categories on the same Web page. An example is Yahoo!, where every visitor to the site sees the same display of information categories and these categories range from news to shopping, e-mail, entertainment and so on. They aim to provide all the information a person could be seeking on the Web. Vertical portals (vortals) on the other hand, provide information on a single subject, closely related subjects, or information directed at particular groups of users. Vortals can provide a unique view to a user by recognizing the user class to which they belong, through an authentication process. This process of displaying only relevant information to the user is called customization (Strauss, 2000).

University Web portals fall under the category of vortals. First colleges created home pages, a static group of links leading to various information categories related to

the university. Now the trend is to display information according to user class, and some examples of this are the 'My UCLA' (the Web site of the University of California, Los Angeles) and 'MyUW' (the University of Washington Web site). The above portals provide customization and personalization options to the users. This is how they implement -- Personalization is the process by which users can select only those topics that they want displayed on their view of the Web page. Customization is the process by which the system displays information relevant to the user by recognizing user class (See Figure 2). There is literature on user acceptance of customized Web pages but no published research is available to indicate user acceptance of a customized or tailored Web portal (Eisler, 2000).

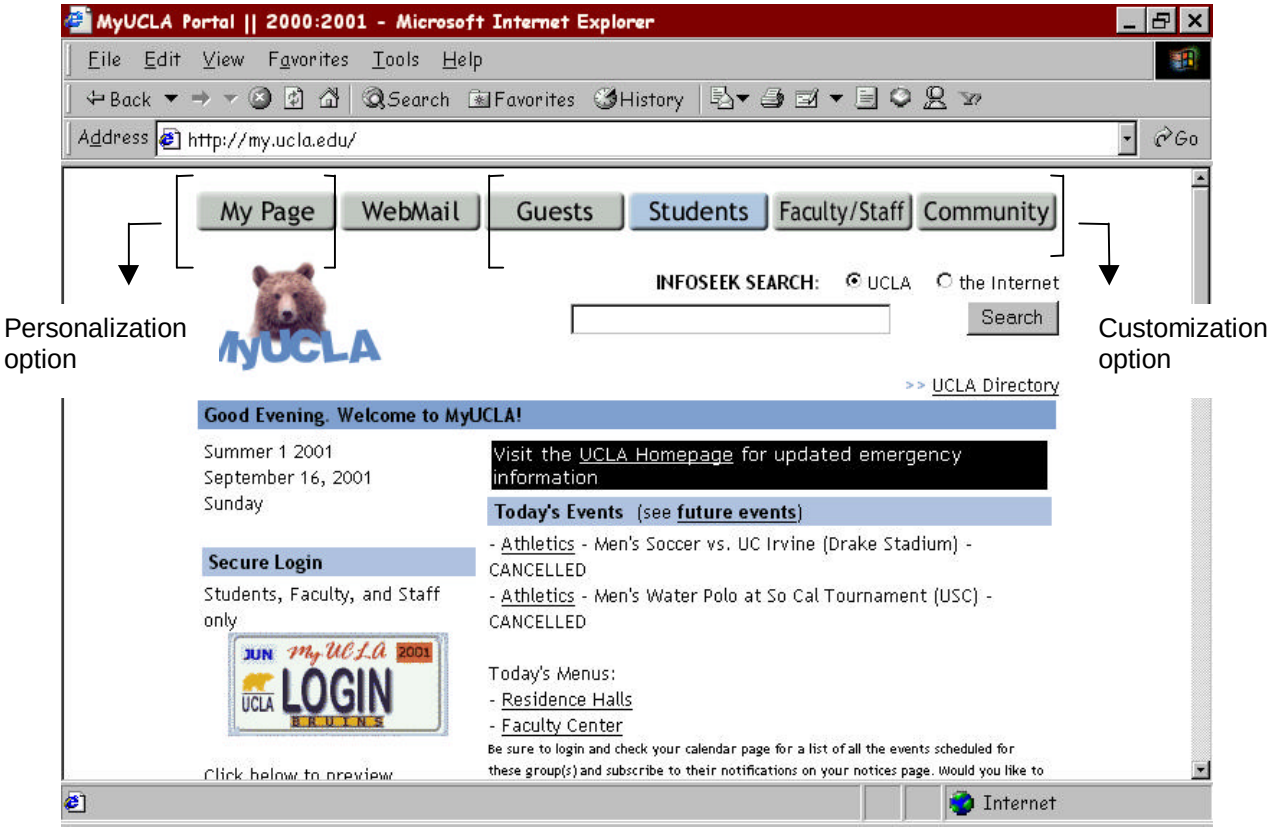

Figure 2. Personalization and customization on the 'MyUCLA' Web page

The study determined if content customization on a Web portal increases ease of access of information. It also determined if a tailored presentation style for that customized information increases ease of access. Based on this determination, process recommendations were developed for tailoring content to a specific user class and presenting the tailored content to facilitate better information access for the users. A set of metrics based on the two HCI theories was used to compare information presentation styles for Web portals.

1.2.2. User-centered and Participatory design

Designing a system from the user's point-of-view to ensure easy usage is called user-centered design. According to Norman (1988), user-centered design is a design approach that takes into consideration the needs and interests of the user with the objective of making products usable and understandable. According to Rubin (1994), user-centered design is a set of techniques and procedures for designing usable systems with the user at the center of the process.

User-centered design is facilitated by participatory design. According to Hix and Hartson (1993), user-centered design is the process of getting users involved in interaction development. The authors suggest that the key payoff of participatory design is that the designers benefit from the knowledge domain that the users have. The authors also say that if the interface is a computer interface, then the users can tell the designers or demonstrate through their performance of tasks, what was easy and difficult to accomplish, using the interface. This can provide the designers with concrete data to use as a basis for making changes to the interface and make it easier to use.

In the study, participatory design was used to design the tailored prototypes of the 'Academics' portal page. In Study 1, requirements were gathered from the users, and in Study 2 the users' task performance with the prototypes were analyzed. The users were undergraduate students, one of the user classes for an academic portal. In Study 1, user input on their preference for academic content was elicited through ratings and rankings. In Study 2, user task performance was measured with metrics developed on the basis of HCI theories. In Study 2, user input was also elicited on the order of information categories displayed and descriptions used for each category. In this manner, participatory design was used in the study (Both in Study 1 and Study 2).

1.2.3 Redesign of the Indiana University Web site

There is limited research on the user acceptance and use of University Web sites. The following is one of the few published research studies in this area.
A study was conducted at Indiana University to redesign their existing Web site and make it user-centered. Usability testing was also conducted to ascertain that the Web site was easy to use (Corry, Frick and Hansen, 1997).

The need for the study arose when administrators at the Bloomington campus of Indiana University recognized that their World Wide Web site was becoming an important factor in recruiting new students and also serving the information needs of its various user classes: existing students, faculty, staff and alumni. An interdisciplinary team that comprised faculty and staff members and graduate students developed a user-centered design for the Web site. The University Computing Support was not sure if the existing Web site was providing users with the information that they sought or how easy it was for the users to find information. So the main task the team undertook was to determine the usefulness of the existing site and develop a new site if necessary that would meet the user needs more effectively.

The needs analysis phase was conducted by collecting the ten most frequently asked questions and approximating the frequency of each from thirty-five campus offices and departments that had a high volume of phone calls, in-person visits and e-mails. The above phase yielded three hundred and thirty nine questions that were most frequently asked. Through a card sort procedure, the questions were classified under thirty different categories. The categories were in turn organized into six main categories of information. Another aspect of the requirements gathering phase was to note the exact terminology used for the different topics that were part of the frequently asked questions set. The terms were used in building the first prototype for testing.

The first prototype was built using paper. Paper prototypes of the existing and proposed Web sites were tested on participants drawn from the demographics being targeted by the university, namely, current and potential students, parents, faculty, staff and alumni. The participants were provided with the paper prototypes and a set of questions. The participants were required to locate answers to these questions using the paper prototypes. Verbal protocols were collected as the participants carried out the tasks. The problem areas identified this way were backward movements because of selecting incorrect pages and some instances where the participant was not able to find a path to the required information, leaving the task incomplete. The result of this phase of testing was that the proposed site out-performed the existing design in terms of ease and speed of locating information. A second phase of usability testing was done using paper prototypes where some problems identified in the first phase were addressed.

Two phases of computer testing followed, using computer versions of the existing and proposed Web sites. The first phase helped identify usability issues like too many key presses and too much scrolling. These problems were addressed before the second test phase. The overall results were that the proposed site was more user-friendly than the existing site especially in terms of the ease of locating information.

The study conducted by the author of this document is similar to the above study. In this study, aspects of information design and presentation were focused on, while comparing the existing and tailored information presentation styles. In the Indiana University study, usability aspects like scrolling and key presses were tested in addition to ease of information location. While the Indiana University study was conducted to determine the best design for the entire Web site and content was designed and organized from the beginning, the study conducted by the author aimed to determine the best information presentation style for a particular Web portal and for that purpose, existing information design was tailored to the requirements of a specific user class. As a part of the research objective, metrics were developed on the basis of two HCI theories to measure user acceptance of alternative designs. Another difference between the two studies is that the author's study involved remote data collection (online). Requirements gathering and prototype testing were done over e-mail and the Internet respectively. The remote data collection technique is easier and more cost-effective than laboratory-based testing of prototypes. (See the Procedure and Discussion sections for details about the technique).

1.2.4. Information Foraging Theory

Information Foraging Theory deals with understanding how user strategies and technologies for information seeking, gathering and consumption are adapted to the flux of information in the environment (Pirolli, 2000). According to the theory, there are two kinds of costs associated with navigating a Web site to find information: time costs and resource costs. Time costs refer to the time that is used in finding information and resource costs refer to the users' attention and effort. The structure of information displayed on the Web page should be such that these costs are minimal. A study conducted in 1991 aimed at placing more information into the span of human attention. It followed the principle of reducing the cost structure of information (Card, Robertson and Mackinlay, 1991). In general, people prefer information seeking strategies that yield more useful information per unit cost (Pirolli, 2000).

To put it simply, navigating a Web site looking for particular information involves browsing through the content displayed on a Web page and making a decision as to which link to follow as part of seeking the required information. According to the Information Foraging Theory, users will prefer a content organization that minimizes the amount of time spent on the task and the amount of the users' attention and effort that the task demanded. There are several information presentation styles that can reduce the cost of foraging. An example is the Scatter/Gather browser that progressively refines the search by information category (Cutting, Karger, Pederson and Tukey, 1992). The designer has to determine or compare and test the various information presentation styles that can facilitate minimization of the costs of navigation and information retrieval. In other words, the designer has to find a style that will lead to optimum foraging of information.

Applying Information Foraging Theory to the information design of a Web site or portal can mitigate the effects of 'Information Overload'. Information overload, also called 'cyber space data smog', is the situation where decision- makers are faced with a huge amount of data that they have to navigate in search of particular information. This can lead to user frustration. Organizing information in a 'user-friendly' manner and increasing ease of information access by applying Information Foraging Theory can help reduce user frustration. According to Davydov (2001), user evaluations have shown that users prefer to be able to find information of a high quality without having to spend lots of time browsing and also prefer services that are capable of reducing massive amounts of information into an organized, summarized and customized (from the content interpretation standpoint) set of information.

Information Foraging Theory was applied to the study conducted by the author of this document. Information presentation styles that are based on Information Foraging (prototypes Main-Category-Foraging and Both-Theories) and those that are not (prototypes Control Interface and Description-Scent) were compared and it was determined if one of them is significantly better than the other where reducing the cost of foraging is concerned. The results of Study 2, namely the users' rating of ease of information location on the interface, user perception of information load, the time taken to complete the tasks and a record of errors if any were compared for the presentation

styles. The comparison determined if presentation styles based on Information Foraging facilitates easier information access than the ones that are not. The users rated aspects of the interface according to the metrics -- ease of location of the main category of information and the user's perception of information load. The ratings were compared for the four interfaces to determine if any prototype gained significantly higher user acceptance than the others.

1.2.5. Information Scent

Information Scent has been defined as the users' perception of environmental cues in judging information sources and navigating through information spaces (Pirolli, 2000). Users travel from page to page on a Web site depending on their judgment of the information cues they obtain from a page. So it is important that information cues be designed carefully, as they determine a users' navigation path and ultimately the cost of foraging for information. Where portals are concerned, the user-centered design of information cues is even more important because the portal is a starting point for the users' navigation process.

In exploring and searching for information, users must use proximal cues (cues that they can perceive in their local environment) to judge distal information sources and navigate towards them (Pirolli, 2000). Examples of proximal cues are hyperlinks that are highlighted and underlined so that the user can perceive that they can be followed for more information on that subject. The proximal cues should closely match the distal information sources for them (the proximal cues) to provide a strong information scent to the users.

In the study, requirements gathering (Study 1) involved obtaining user ratings of keywords that serve as descriptions for each main category of information that is displayed on the portal (See Figure 1). The five keywords that were rated best (in other words, keywords that the users thought, best described the corresponding information category) by the participants were used as descriptions for the main categories. Thus, the process involved obtaining a user rating of information cues and the ones rated the best (according to user perception of relevance) were the ones that provided the strongest information scent. The objective was to capture the terminology the users are familiar with or prefer to use while referring to topics of academic information. The keywords obtained in the requirements gathering were incorporated into the tailored prototypes (prototypes Description-Scent and Both-Theories) for testing.

Users find it difficult to read text on a computer screen and so they rarely read the full text but instead scan the text and pick out words of interest. A study performed by Nielsen and Morkes showed that seventy-nine percent of the users tested scanned a new page they came across and the remaining users read text word-by-word (Nielsen, 2000). The above concept of 'scannability' was applied to the tailored prototype building process in the proposed study. The tailored prototypes contained the descriptions in the form of user-rated keywords instead of long sentence descriptions for each main category. The existing design for the academic page has descriptions in the form of

sentences as well as keywords but they were not designed with a user-centered approach. The tailored prototypes had the descriptions in the form of keywords only and they were keywords that were rated highest by users themselves during requirements gathering.

The information scent of the keywords was tested during Study 2 where the users were asked to rate the keyword descriptions according to how clearly they described the target information that the users were asked to locate. The metric that was used for the rating is "intuitiveness of the description".

1.3. RESEARCH OBJECTIVE

The aim of the study was to determine if an information presentation style that is tailored to user preferences (on the basis of either or both HCI theories Information Foraging and Information Scent), is easier to use for information location than a presentation style that was not developed with a user-centered approach. In order to make the above decision, users' ratings of ease of access, perception of information load and 'intuitiveness' of information cues on the prototypes were compared for the four presentation styles. Time taken for information location and errors committed during the same, were also recorded and compared for the four prototypes. The ratings were done on a set of metrics derived from the theories of Information Foraging and Information Scent.

CHAPTER 2. REQUIREMENTS GATHERING (STUDY 1)

The study consisted of user requirements gathering (Study 1) followed by a translation of the results of requirements gathering into process recommendations for tailoring of portals. The recommendations were used to build prototypes of the academic Web portal based on the two HCI theories. The tailored and existing prototypes were tested in the prototype-testing phase (Study 2). The following section describes Study 1.

2.1. OBJECTIVE

The objective of Study 1 was to gather requirements from the one of the user classes of the academic information portal (undergraduate students) regarding their academic information needs. The results of Study 1 served as a basis for tailoring information on the academic portal prototypes according to user preference, for Study 2.

2.2. PARTICIPANTS

Ten undergraduate students were recruited for Study 1. The undergraduate students were recruited from various departments with the help of faculty and staff members. The basic requirements for participation were:

- The participants needed to have access to a computer with Internet. While answering the requirements gathering questionnaire the participants may have needed to access the Academic portal of the Virginia Tech Web site (Figure 1) for reference.
- The participant was required to have at least one year of Internet browsing experience. The proposed study aimed to determine the ideal information presentation style for a Web portal that will be accessed by university students. Students generally have adequate exposure to the Internet by the time they join a university. The aim of the study was to determine the ideal information presentation style for a user with intermediate experience with the Internet and not for a novice user.
- The participant should not have taken courses related to software usability. A formal knowledge of usability principles possessed by a user could produce a bias. The aim of the study was to determine the ideal information presentation style from the point-of-view of the average user of a University Web site, who does not have knowledge of the concepts of software usability and HCI principles. As a result, it was important that the participants not possess knowledge of the above-mentioned concepts. The participants were paid seven dollars for their participation in the study.

2.3. MATERIALS

The questionnaire for Study 1 (Appendix A) was prepared in MS Word and emailed to the participants as a document file. The participants of Study 1 needed access to a computer with Internet access so that they could receive the questionnaire from the experimenter by electronic mail and send it back after answering it.The participants were required to have MS Word on their computers in order to open the questionnaire and enter their responses into it.

2.4. PROCEDURE

An informed consent form (Appendix B) was sent to each participant through e-mail along with the questionnaire. The participant was asked to read it and indicate their consent by typing their name in the space at the bottom of the form. The act of typing their name acted as an equivalent to a participant signature.

The participants answered the questionnaire included in Appendix A. The participants were provided with a list of main categories of academic information that were present on the existing academic portal. They were asked to rate the main categories according to relevance on the following scale:

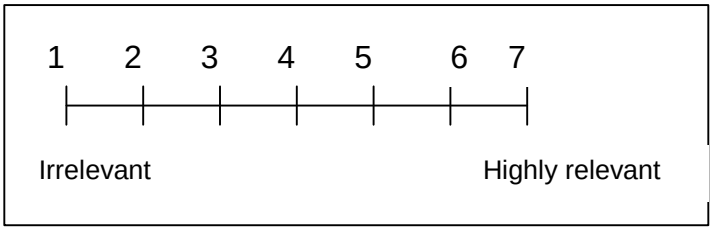

Figure 3. Rating scale for relevance of main categories

The above scale is a semantic differential scale with a rating of 1 for irrelevant topics and a rating of 7 for the most relevant topics. In addition to providing a rating, the participants were asked to rank order the main categories without providing the same rank for two or more categories.

The second part of Study 1 involved a user rating and rank ordering of keywords associated with each main category, which were provided. The participants were asked how clearly the keyword described the corresponding main category. The scale used for rating is as follows:

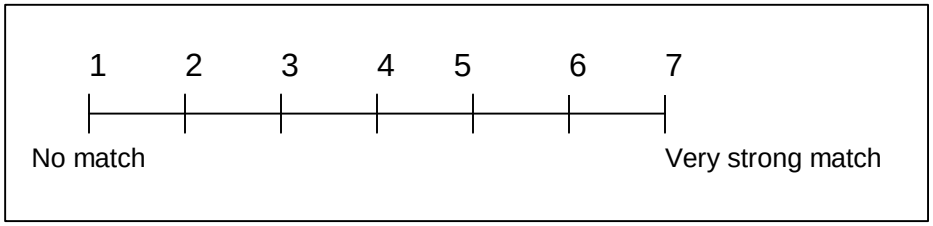

Figure 4. Rating scale for match between keywords and the corresponding main category

The participants were asked to add any keywords of their choice that they thought described each main category, but were not on the list provided. The participants were then asked to rank order according to preference, the keywords for each main category without assigning the same rank to two or more keywords.

2.5. DATA ANALYSIS

The rating and rank ordering of each main category (obtained from the first part of Study 1) were multiplied to obtain a weighted factor. The average of the ten weighted factors were obtained. The main categories were arranged in increasing order ofweighted factor, which was decreasing order of user preference. The participants' rating of relevance of information categories provided the designer with the undergraduate students' academic information requirements. The process was based on Information Foraging, which says users want to see their most preferred topics first in order to reduce the time taken for browsing information.

The rating and rank ordering for each keyword (obtained from the second part of Study 1) were multiplied to obtain a weighted factor. The average of the ten weighted factors obtained from ten participants were averaged again. The keywords were arranged in increasing order of weighted factor, which was decreasing order of user preference. The five keywords with the lowest weighted factors (five keywords most preferred by users) were included in the description part of the tailored prototypes Description-Scent (Figure 7) and Both-Theories (Figure 8).

The above procedure is in accordance with the concept of Information Scent. Displaying the keywords that best describe the category of information provides a strong information scent to the users and makes their information location tasks easier.

2.6. RESULTS

The results of Study 1 were a list of main categories of information and a list of keywords for each main category, both in decreasing order of user preference. The lists

were used to build the tailored prototypes Main-Category-Foraging, Description-Scent and Both-Theories, for Study 2. Table 1 contains the main categories and keywords in order of user preference and the means and standard deviations of the weighted factors of each main category and keyword.

Table 1. List of main categories, descriptions and their weighted factors, in decreasing order of user preference

Main Category	**Weighted Factor**		**Description**		
	Mean	**Standard Deviation**	**Keyword**	**Weighted Factor**	
				Mean	**Standard Deviation**
Hokie SPA	2.0	1.7	Student accounts	1.3	0.67
			Registration information	2.2	1.55
			Student status	3.7	1.77
Classes, catalogs, courses and exams	8.3	4.9	Class timetables	1.3	0.48
			Academic calendars	3.1	1.73
			Exam schedules	18.4	7.15
			Online course information and materials	21.7	4.57
Colleges and departments	14.9	8.28	Departments	3.3	1.77
			Overview of college	9.8	2.86
			Scholarships	12.1	3.14
			Academic affairs	13.8	3.79
Libraries	18.2	7.3	Addison	1.3	0.48
			Journal databases	5.2	4.07
			Electronic reference shelf	13.7	4.08
			Virtual tour	24.2	6.73
			How to do library research	29.6	3.44
University core curriculum	21.2	8.82	Core curriculum worksheet	12.3	3.37
			Writing intensive courses	20.9	4.25
			Curriculum goals	27.9	6.02

Table 1(continued)

Main Category	Weighted Factor		Description		
	Mean	Standard Deviation	Keyword	Weighted Factor	
				Mean	Standard Deviation
			Ideas, cultural traditions and values	29.7	4.19
			Society of human behavior	35	0.0
Fees and tuition	24.8	7.84	Tuition and fees	3.9	2.6
			Student refunds	14.8	5.05
			Budget tuitions	20.8	3.77
			Deadlines	27.7	6.02
			Direct deposit	35	0.0
Office of the university registrar	32	8.18	Academic calendar	2.2	1.23
			Class timetables	4.0	2.31
			Holidays	4.7	2.98
			Transcripts	13.8	5.3
			Exam schedules	25.0	4.9
Academic programs	36.3	8.21	Career services	6.1	3.4
			Counseling center	8.0	3.7
			Writing center	14.2	2.7
			Academic assessment	16.0	4.12
			CAEE Honor System	27.8	4.08
Guide to majors	48.2	9.34	Specializations	6.2	3.26
			Employment outlook	9.7	2.95
Course information student page	60.3	5.8	Course listings	2.2	1.87
			Course information	3.2	2.66

Table 1(continued)

Main Category	Weighted Factor		Description		
	Mean	Standard Deviation	Keyword	Weighted Factor	
				Mean	Standard Deviation
Summer sessions information	62.6	12.03	Timetable of classes	5.3	1.89
			Tuition and fees	6.0	3.46
			Registration	7.3	3.59
			Exam schedules	9.2	3.46
Commencement information	72.4	9.35	Dates	4.2	1.40
			Locations	4.9	3.2
			Guest seating	12.0	6.7
			Parking	14.0	4.49
			Events	14.9	5.72
Graduate school	77.4	7.86	Applications	3.3	3.02
			Funding	4.1	3.12
			Support	7.2	3.08
			Policies	15.9	6.21
Extended campus programs	79.7	6.55	Centers	8.0	3.23
			Enrolment	12.4	4.74
Distance and distributed learning	84.4	11.49	Courses offered	1.3	0.48
			Degrees	7.3	4.57
			Calendar	8.2	4.8
			Student support	24.0	6.72
Electronic campus of Virginia	97.8	9.2	Courses	1.3	0.48
			Degrees	7.2	4.02
			Calendar	8.1	4.28
			Student support	24.0	5.58

CHAPTER 3. PROTOTYPE BUILDING

3.1. TRANSLATION OF USER REQUIREMENTS INTO PROCESS RECOMMENDATIONS

The next step was to consolidate the results of the requirements gathering and form a basis for building the three tailored prototypes. Table 2 below, specifies which aspects of each prototype (main category or description) were tailored according to user importance ranking. The table also summarizes the theories that were applied to the construction of the prototypes. A more detailed explanation of the tailoring process is included in section 3.2 (Prototype Building).

Table 2. Prototypes that were built on the basis of user requirements and HCI theories

Prototype	Main category	Description	Theory
Control Interface	Not Tailored	Not Tailored	None
Main-Category-Foraging	Tailored	Not Tailored	Information Foraging
Description-Scent	Not Tailored	Tailored	Information Scent
Both-Theories	Tailored	Tailored	Information Foraging and Information Scent

The list of main categories of information obtained from Study 1 was used as a basis for tailoring information in the prototypes that were built. Three tailored prototypes were built – Main-Category-Foraging, Description-Scent and Both-Theories.

Main-Category-Foraging (Figure 6) contained the main categories rated as relevant by the participants in Study 1, in order of user preference but the descriptions stayed the same as the existing expert-generated information design. The prototype was thus built on the basis of Information Foraging Theory.

Description-Scent (Figure 7) contained the keywords rated by users as the most intuitive descriptions for each main category in Study 1 but the order of main categories was the same as the existing expert-generated order. Not more than five keywords were listed for each main category so as to avoid information overload on the portal. The prototype was thus built on the basis of Information Scent.

Both-Theories (Figure 8) contained the main categories in order of user rating and also five keyword descriptions rated as most intuitive by the users of Study 1. The prototype was built on the basis of both Information Foraging Theory and Information Scent. Figure 5 represents the Control Interface, which was built according to expert-generated main categories and descriptions and not according to user preference. No theory was applied to the design of the Control Interface.

Figure 5. Control Interface --Prototype with expert-generated main categories and descriptions

Figure 6. Main-Category-Foraging -- Prototype with user-generated order of main categories

Figure 7. Description-Scent -- Prototype with user-generated descriptions

Figure 8. Both-Theories -- Prototype with user-generated order of main categories and descriptions

3.2. PROTOTYPE BUILDING

The three tailored prototypes were built using Microsoft Word, following the process recommendations obtained from Study 1. A prototype of the existing information design was also built, for Study 2. All the four prototypes had one main page and one level of satellite pages. The look-and-feel of all prototypes was the same. The content and content presentation, differed according to the translation of the results of Study 1 to process recommendations (See Table 2).

Each prototype consisted of a main page and one level of satellite pages. The above means that clicking on a hyperlink on the main page took the user to another page. However the user could not go beyond this level since the second page had no hyperlinks. The reason for designing the prototype with just one level of satellite pages was that ease of information access on the portal was being measured, and not the navigation process through the entire Web site.

Table 3. Tailoring of content of each prototype

Prototype	Details of tailoring	Theory applied
Control interface	Expert-generated order of main categories and expert-generated descriptions	None
Main-Category-Foraging	User-generated order of main categories and expert-generated descriptions	Information Foraging
Description-Scent	Expert-generated order of main categories and user-generated descriptions	Information Scent
Both-Theories	User-generated order of main categories and user-generated descriptions	Information Foraging and Information Scent

CHAPTER 4. PROTOTYPE TESTING (STUDY 2)

4.1. OBJECTIVE

Study 2 involved testing the prototypes on undergraduate users. The aim of Study 2 was to determine if there is a significant difference in user ratings of ease of access, perception of information load and intuitiveness of descriptions and measures of time taken for information location and errors during information location among the four prototypes.

4.2. RESEARCH DESIGN AND HYPOTHESES

A 2×2 factorial design was used for Study 2. A between-subjects design was used in order to avoid a confound that may have occurred through practice. If the same participant was exposed to all presentation styles, his/her performance with a particular presentation could be biased by exposure to the previous style or styles.
The two factors in the research design were:
1. Main category
2. Description

The factor Main Category had two levels. Level 1 was expert-generated. The prototypes associated with this level had main categories that are displayed on the portal according to the existing design, which is based on the decision of the Web design team of experts. Level 2 was user-generated. The prototypes associated with this level had main categories tailored to user requirements gathered in Study 1.

Similarly, the factor Description had two levels. Level 1 was expert-generated and Level 2 was user-generated. Level 1 had prototypes with descriptions decided by the Web design expert team and Level 2 included descriptions tailored to user requirements gathered in Study 1. Table 3 summarizes the tailoring applied to each prototype. The research design for Study 2 is shown in Table 4.

Table 4. Research design for Study 2

Description	**Main Category**		
		Level 1 Expert-generated	Level 2 User-generated
	Level 1 Expert-generated	(No theory)	(Information Foraging)
	Level 2 User-generated	(Information Scent)	(Both Theories)

The two independent variables or factors were 'Main category' and 'Description'. The dependent variables that were measured are -- ease of information access, users' perception of information load, 'intuitiveness' of descriptions, time taken to perform the tasks and errors while performing tasks.

Hypothesis 1: The prototypes with user-generated order of main categories will yield significantly better ratings of ease of access and perception of information load and significantly better measures of errors and time for information location than the prototypes with expert-generated order of main categories.

Hypothesis 2: The prototypes with user-generated descriptions will yield significantly better ratings of intuitiveness of descriptions and significantly better measures of errors and time for information location than the prototypes with expert-generated descriptions.

Hypothesis 3: The interaction between Main Category and Description will be such that the prototype with user-generated order of main categories and descriptions will obtain significantly better ratings of ease of access, perception of information load and intuitiveness of descriptions and significantly better measures of time for information location and errors during information location than the prototypes where the order of main categories and/or descriptions is expert-generated.

Hypothesis 1 was tested by interpreting the main effect of Main Category. Hypothesis 2 was tested by interpreting the main effect of Description. Hypothesis 3 was tested by interpreting interactions between Main Category and Description.

4.3. PARTICIPANTS

Forty undergraduate students were recruited as participants for Study 2 from various departments of Virginia Tech with the help of faculty and staff members. The participants were paid seven dollars each after they participated in the study.

The basic requirements for participation were:

- The participants were required to have access to a computer with Internet. Study 2 involved information location tasks to be performed on a portal prototype that was built and uploaded on the laboratory server. The URL of the prototype was provided to the participants and they were asked to access it on a computer and perform the tasks that were included in a questionnaire attached to each prototype.
- The participants were required to have at least one year of Internet browsing experience. The study aimed to determine the ideal information presentation style for a Web portal accessed by university students. Students generally have adequate exposure to the Internet by the time they join a university. So the users of the prototypes being tested will have at least an intermediate level of Internet browsing experience and are not novice users.
- The participants were required not to have taken courses related to software usability. A formal knowledge of usability principles possessed by a user could

produce a bias. The aim of the study was to determine the ideal information presentation style from the point-of-view of the average user of a University Web site, who does not have knowledge of the concepts of software usability and HCI principles.

4.4. MATERIALS

The Perseus software was used to generate a survey questionnaire to test the prototypes remotely. Although the study was not a usability study, user performance measures (time for information location and errors) were recorded. Time was recorded by embedding a Java script for that purpose in the source code of the prototype and uploading additional Perl scripts in the CGI-bin of the server. Microsoft Word was used to build the prototypes and attach them to the questionnaires generated with Perseus.

4.5. PROCEDURE

After forty potential participants were recruited, they were randomly assigned to the four prototypes. Ten participants were assigned to each prototype. The above system avoided a bias that could occur due to the exposure of the same participant to more than one prototype. Each participant was sent a URL for the survey and a participant code by email. When they entered the URL in their browser, an HTML page was displayed where they were asked to enter their participant code and click the <Submit> button (Figure 9).

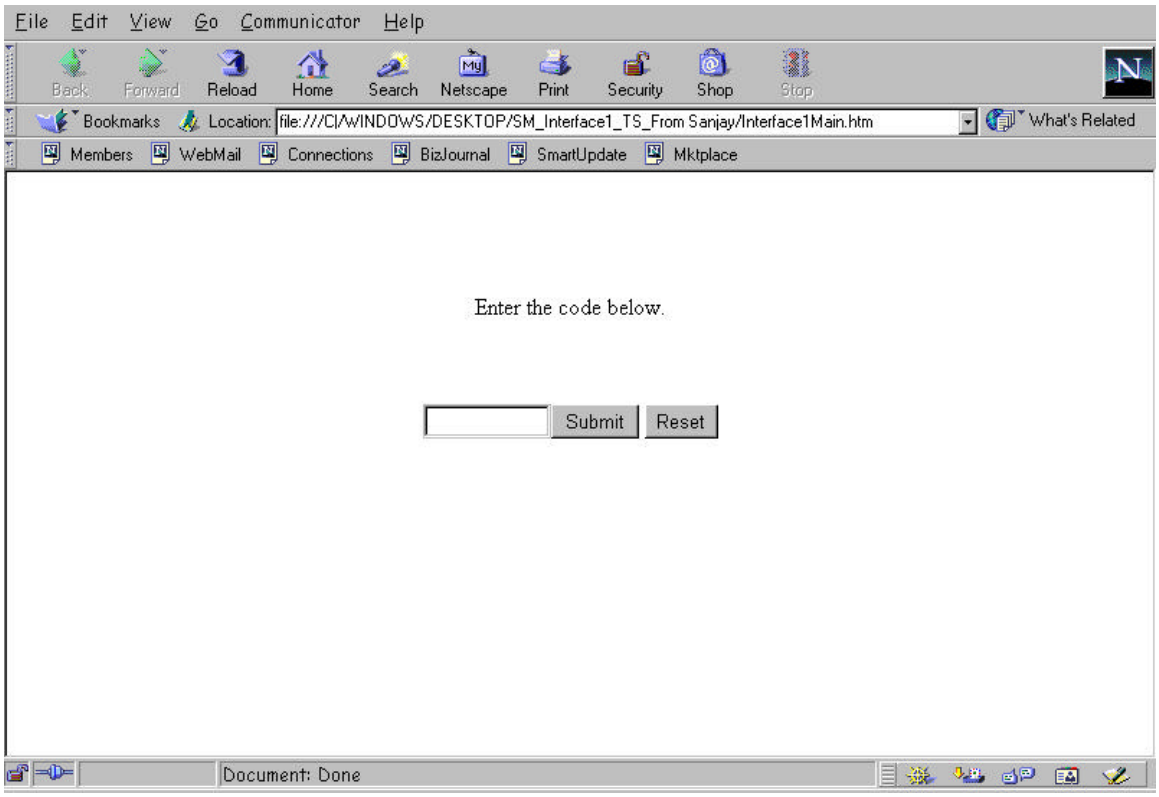

Figure 9. Start page

When the above was done, a page with a button "Continue to survey" was displayed. When the button was clicked, an HTML page with the prototype in the top frame and the questionnaire in the bottom frame was opened (Figure 10).

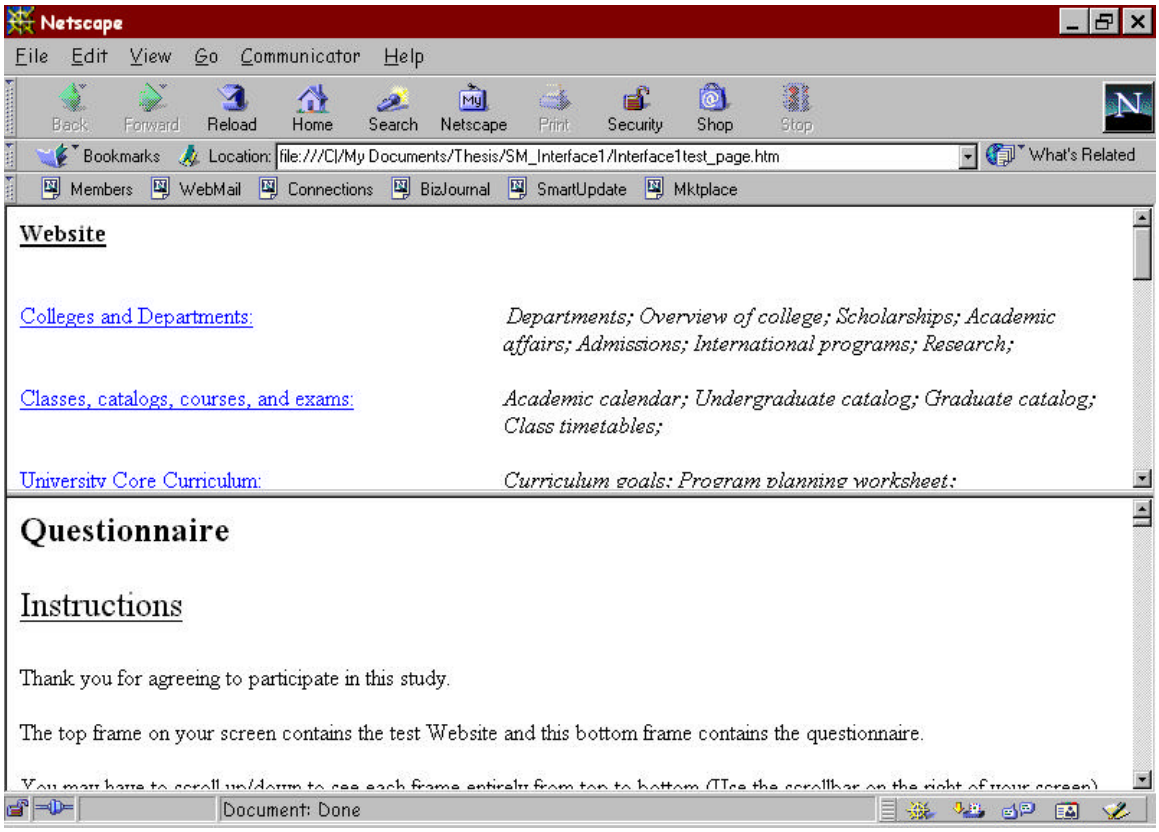

Figure 10. Main page for prototype Control Interface (Survey and prototype)

The participant was asked to read the instructions in the questionnaire and also read the informed consent and type their name in the space provided. The above action was equivalent to the participant signing the informed consent. The participants were also asked to enter their SSN and postal address for payment purposes. The complete questionnaire for the Control Interface can be found in Appendix D. The questionnaire was the same for all four groups of participants except that the order of questions varied. This was done because there was a difference between the order of main categories of Control Interface and Main-Category-Description and also between Description-Scent and Both-Theories (Refer Table 3 for an explanation of how the order of main categories differed for the prototypes). Since each main category had a task associated with it (sixteen tasks in all), care had to be taken to ensure that the order of questions and order of main categories were not the same for any given prototype.

While performing the tasks, when a participant clicked on a hyperlink, a satellite page with an alphanumeric code was displayed (Figure 11 has the satellite page for the first main category of Control Interface).

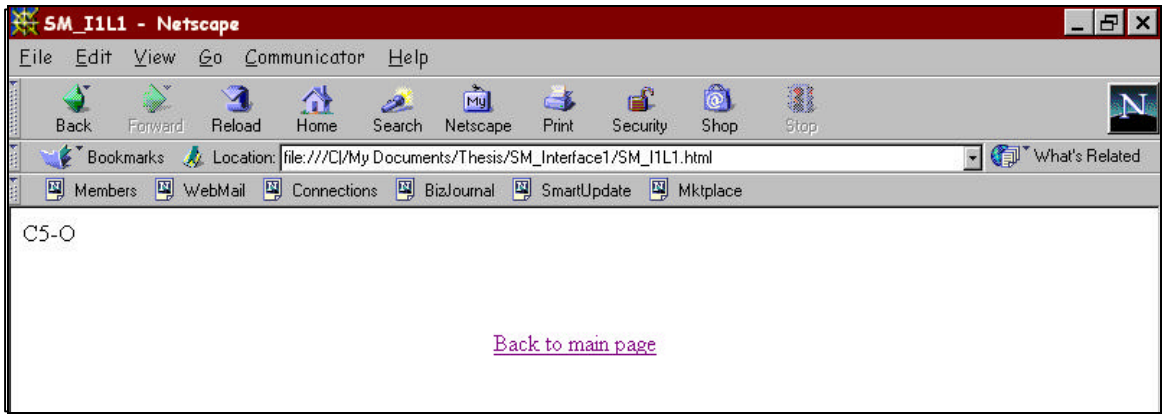

Figure 11. Satellite page for first hyperlink of Control Interface.

The tasks were designed with the objective of measuring ease of information access and how clearly the descriptions matched the main categories. The participant was asked to locate a piece of information that required a decision about which main category on the main page or portal contains that information. The participant also used the description alongside a main category to make that decision. The participant then acted on the decision made and followed the appropriate link on the main page to locate the information. A questionnaire attached to the prototype contained detailed instructions and the sixteen tasks the participant was asked to perform.

For example, one of the tasks was to locate the date for the final exams. When faced with this task the participant was supposed to browse the list of topics on the main page of the prototype and decide which category would lead them to the desired information. The participant was also asked to read the description alongside the main categories to help make the decision. Once the participant selected one of the hyperlinks and clicked on it, they were taken to a satellite page with an alphanumeric code. The participants were given prior instructions to enter the code in the space provided in the questionnaire. The participant was asked to repeat the above process for all sixteen tasks.

After performing each task the participant was asked to rate ease of access, perception of information load and 'intuitiveness' of descriptions. The above- mentioned metrics were rated on the following scales respectively:

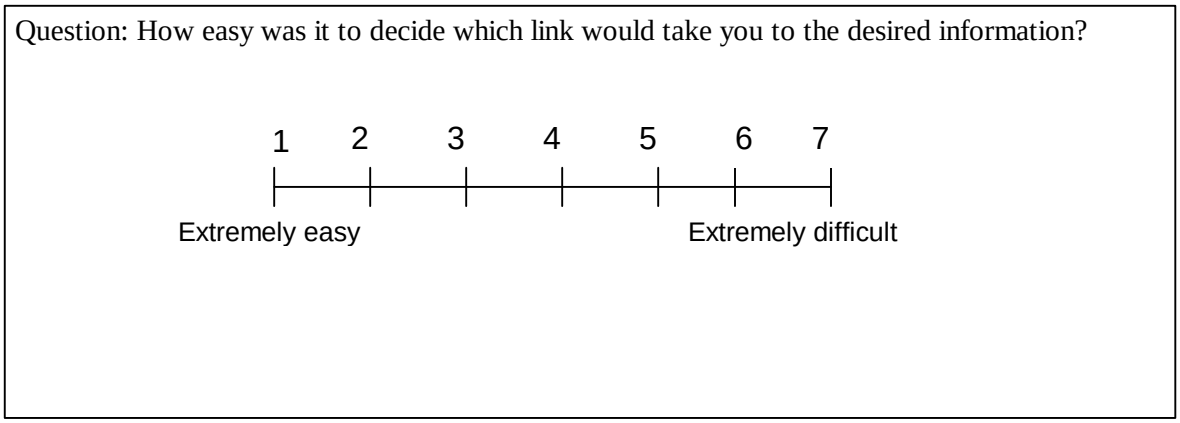

Figure 12. Rating scale for ease of access

The rating of ease of information access is a metric that indicates the user's perception of the ease of information foraging. The Information Foraging theory is one of the HCI theories that were used to tailor the information content and presentation according to user preference. An information presentation style that increases ease of access makes the information foraging process easier for the user.

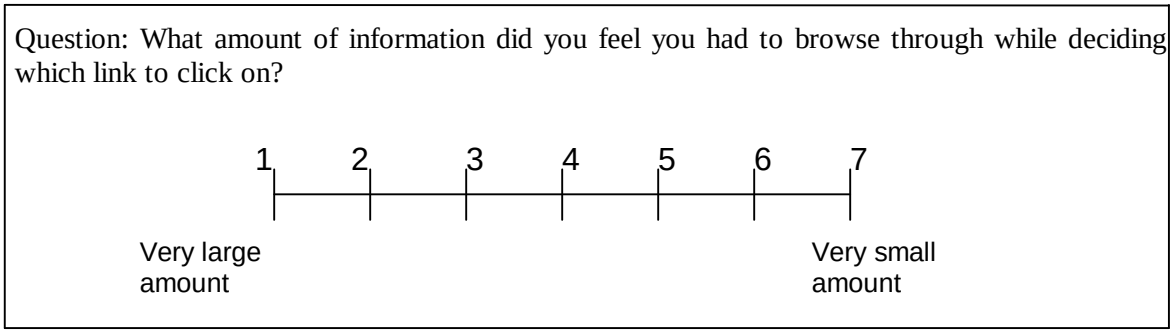

Figure 13. Rating scale for user perception of information load

The users' perception of information load was recorded because information load is an important factor in information foraging on the Web. Information overload hampers the efficiency of information foraging. An ideal information presentation style should minimize information load so as to provide the user with optimum amount of information to browse while looking for a specific topic.

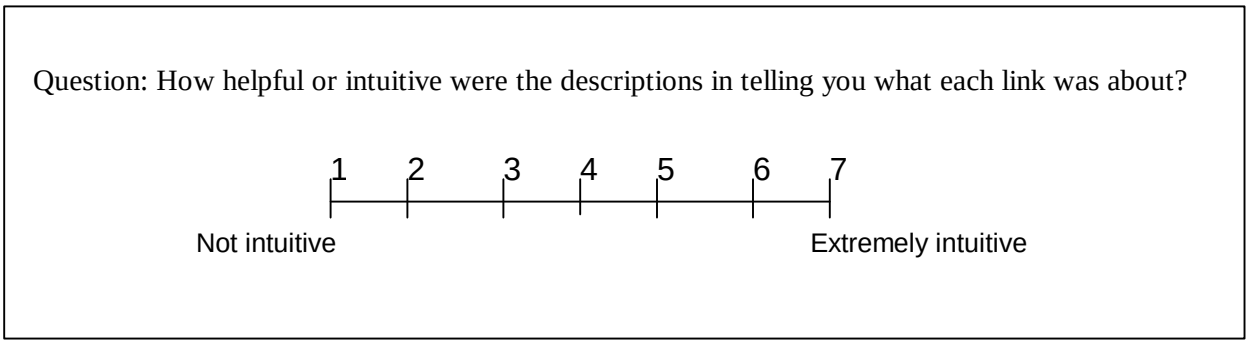

Figure 14. Rating scale for intuitiveness of information cues

The users' rating of the intuitiveness of the descriptions is a metric that indicated the information scent provided by the proximal cues (descriptions). The stronger the information scent the easier it is for the user to locate the necessary information. The above-mentioned metric is thus based on the concept of Information Scent. A summary of the three metrics and the theories they were derived from is shown in Table 5 below.

Table 5. Summary of metrics derived from theories

Metric	**Derived from HCI Theory**
Ease of access	Information Foraging
Perception of Information load	Information Foraging
Intuitiveness of descriptions	Information Scent

At the end of each task, the participant was asked to enter the alphanumeric code on the satellite page they reached while performing the task. This was done to give the experimenter a way of recording errors. If the participant clicked on the correct link for a particular task, they reached a satellite page with the correct alphanumeric code for that task. Although the participant was not able to determine if they reached the correct satellite page, the alphanumeric code that they entered in the questionnaire told the experimenter if they clicked on the correct link or not.

The time taken to do each task was recorded by embedding Java scripts in the source code of the various HTML pages accessed by the participant and uploading Perl scripts on the server. The scripts were able to record the time at which a user clicked on a hyperlink on the main page, thus accessing a satellite page of the prototype. The above method helped record the time the user took to decide which category on the portal would lead them to the target information they were asked to locate. Appendix C has a detailed explanation of all the codes used for time-stamping.

At the end of the survey, the participant was asked to click on a <Submit> button that would automatically e-mail the completed survey to the experimenter and also save a copy on the server. A file with the time at which each hyperlink was clicked on, was automatically created and saved on the server for each participant.

A pilot test conducted prior to data collection brought to the notice of the experimenter that the surveys could be accessed without any problems using the Internet Explorer browser but could not be accessed using the browser Netscape Navigator. The problem was fixed by making adjustments to the HTML scripts in the source code of the prototypes so that they could be accessed without problems using either one of the above Internet browsers.

The entire process of data collection for Study 2 was done remotely. The users as well as the experimenter were away from the laboratory server where the surveys were situated and survey responses uploaded. The server was part of a university laboratory in Blacksburg, Virginia, and the users accessed the surveys from their personal computers or campus computer centers and laboratories. The experimenter was in a different town, and accessed e-mail to obtain the survey results from a personal home computer. Using Perseus, the laboratory server was set up to email the results of each survey to the experimenter, as soon as the results were submitted by a participant with a click of the <Submit> button at the end of the survey. The time-stamps, which were saved on the server dynamically as the participant performed tasks with the prototype, were transferred from the server to the local computer of the experimenter every night, using software called pcAnywhere. The software allowed the experimenter to log on to the laboratory server from her home computer in a different town, using a dial-up connection to the Internet, and a user name and password provided by the system administrator. After connecting to the server using the above method, the experimenter copied the time-stamps stored on the server, to her personal computer.

The system administrator also provided assistance to the experimenter by uploading the time-stamp Perl scripts and the files containing the surveys and prototypes, in appropriate directories on the server. The above process was carried out prior to pilot testing and data collection.

4.6. DATA ANALYSIS

The Perseus software recorded the participants' responses for later analysis. The ratings of the respective prototypes according to the three metrics and the user task performance measures of time and errors were collected and compared for the tailored and existing prototypes.

A 2-way Analysis Of Variance (ANOVA) was conducted using SAS software, for each dependent variable (ease of access ratings, perception of information load ratings, intuitiveness of description ratings, time for information location and errors) to measure

the main effects of Main category and Description and the interactions between the two factors. A post-hoc test of Least Square Means was conducted in order to further analyze the interactions that were discovered by the ANOVA, to determine which pairs of cells were involved in the interactions. The means and standard deviations of each variable for each condition, were also obtained using the SAS software.

4.7. RESULTS

The results of the ANOVA and LSMeans are included in Appendix E. The following results were obtained (Table 4 contains a detailed explanation of each prototype):

Hypothesis 1 was partially supported. A main effect of the factor Main Category on the dependent variable time was found. *F(1,36) = 4.43, p=0.0424 (p<0.05 level of significance)*. The analysis showed that the time taken to perform tasks was significantly lower for the prototypes Main-Category-Foraging and Both-Theories *(M=743.2, SD=159.83)* as compared to the prototypes Control Interface and Description-Scent *(M=873.75, SD=227.89)*. The prototypes Main-Category-Foraging and Both-Theories had user-generated order of main categories and the prototypes Control-Interface and Description-Scent had expert-generated order of main categories. Thus hypothesis 1 was supported for only one of the five dependent variables (time for information location). It was concluded that the tailoring of the order of main categories (or using user-generated order of main categories) on the portal used for the study, significantly decreased the time a user takes to decide which path to follow from the portal to the target information. It was also concluded that the tailoring of the order of main categories did not significantly improve users' perception of ease of access or information load on a portal, or errors in selecting a path from the portal to the target information.

No main effects were found to support hypothesis 2. Thus hypothesis 2 was not supported by the research. It was concluded that tailoring descriptions according to user preference did not significantly improve user ratings of intuitiveness of the descriptions, time taken to decide which path to follow from the portal and errors while selecting a path from the portal to the target information.

Hypothesis 3 was not supported by the study. The prototype Both-Theories did not get significantly better user ratings on the three metrics or significantly less time and errors when compared to the prototypes Main-Category-Foraging, Description-Scent and Control Interface.

Four interactions were found between Main Category and Description. Significant interactions between Main Category and Description were found for the dependent variable ease of access. *F (1,36) = 18.75, p=0.0001 (p<. 0.0001 level of significance)*. Post-hoc analyses revealed that users who used the prototype Main-category-Foraging provided significantly better ease of access ratings *(M = 32.1, SD = 7.77)* than users who used the prototype Control Interface *(M = 44.9, SD = 11.32)* and the prototype Both-Theories *(M = 43.1, SD = 7.29)*. Based on the above result, it was concluded that the

tailoring of main categories significantly increased users' perception of ease of access than the tailoring of the order of main categories as well as tailoring of descriptions and tailoring of neither main categories nor descriptions. Post-hoc analyses also revealed that users who used the prototype Description-Scent *(M = 33.1, SD = 6.27)* gave significantly better ease of access ratings than users of the prototype Control Interface *(M = 44.9, SD = 11.32)* and the prototype Both-Theories *(M = 43.1, SD = 7.29)*. Based on this outcome it was concluded that the tailoring of descriptions according to user preference significantly increased users' perception of ease of access than the tailoring of both main categories and descriptions and neither main categories nor descriptions.

Significant interactions between Main Category and Description were found for the dependent variable intuitiveness of descriptions. *F (1,36)=13.19, p=0.0009 (p<0.001 level of significance)*. Post-hoc analyses revealed that users of the prototype Main-category-Foraging *(M = 91.2, SD = 8.69)* gave significantly better ratings of intuitiveness of descriptions than users of the Control Interface *(M = 78.9, SD = 10.94)* and Both-Theories *(M = 75.5, SD = 8.36)*. Users of the prototype Description-Scent *(M = 84.8, SD = 7.19)* gave significantly better intuitiveness of descriptions ratings than users of Both-Theories *(M = 75.5, SD = 8.36)*.

Another result of the study is the response rate of the participants of Study 2. Thirty-six out of the forty participants responded by completing the questionnaire within the fifteen-day period that was provided (initial response rate was 90%). Four participants responded after a reminder was sent to them after the fifteen-day period had elapsed (after one follow-up the response rate was 100%).

Table 6. Summary of results of Study 2

Dependent variable / **Tailoring**	Ease of access	Perception of information load	Intuitiveness of description	Time	Error
Order of main categories	Significantly better than no tailoring and tailoring both main categories and descriptions	No difference	Significantly better than no tailoring and tailoring both main categories and descriptions	**Significantly decreased (Main effect of tailoring order of main categories)**	No difference
Descriptions	Significantly better than no tailoring and tailoring main categories and descriptions	No difference	Significantly better than tailoring both main categories and descriptions	No difference	No difference
Both order of main categories and descriptions	Significantly worse than no tailoring and tailoring only main categories and tailoring only descriptions	No difference	Significantly worse than tailoring main categories only and tailoring descriptions only	**Significantly decreased (Main effect of tailoring order of main categories)**	No difference

Note: The Cells in bold lettering in Table 6 above refer to the main effect of time that was found as a result of Study 2. The remaining cells represent interactions or no main effect and interaction.

4.8. DISCUSSION

The overall conclusion from the study was that including a user-generated order of main categories on the portal significantly decreases the time taken by a user to decide which main category will take them to the required information beyond the portal. It was also concluded that the tailoring of the order of main categories according to user preference had no clear effect on user ratings of ease of access, perception of information load and intuitiveness of descriptions and on the measures of time for information location and errors. So it was found that the application of the Information Foraging theory to information design on a portal (by tailoring the order of main categories to user preference) significantly decreases time for information location but does not have a clear effect on errors or the users' ratings of ease of access, information load and intuitiveness of descriptions. The above findings can be translated to mean that with regard to errors, and user ratings of the information design, expert-generated information design and

presentation on a portal does not significantly differ from a user-generated information design and presentation.

Web designers can use the main recommendation that emerged from the study, namely, user-generated order of main categories significantly decreases time for information foraging. The order of main categories generated by the users of the academic information portal can be found in Table 1, which is the result of Study 1.

The interactions showed that ease of access was rated better by users for the prototypes where Information Foraging was applied and where Information Scent was applied when compared to the prototypes where both theories were applied and where neither theory was applied. An interaction showed that users rated intuitiveness of descriptions better for the prototype where Information Foraging was applied than the prototype where neither theory was applied, although both prototypes had the same descriptions. The interaction also showed that users of the prototype where Information Scent was applied gave higher intuitiveness of descriptions ratings than the users of the prototype where both theories were applied.

The study showed that the remote data collection method used was time- effective and cost-effective. The entire process took around fifteen days. The study showed that MS Word and Perseus could be effectively used for the remote data collection process to build the prototypes and questionnaires. It was also concluded that pcAnywhere is an effective tool for the experimenter to obtain raw data stored on the remote server, as was done in Study 2.

CHAPTER 5. CONTRIBUTIONS

The results of the statistical analyses revealed that tailoring the order of main categories of information according to user preference can significantly decrease time taken by a user to locate information on a portal. Web portal information designers can use the above recommendation to ensure that users take less time to find required information on the portal. The order of main categories that was generated by users (Table 1) can be used by university academic portal designers as process recommendations in order to minimize time for information location on the portal.

A valuable contribution of the study is the remote data collection technique employed in Study 2. The technique proved to be time-effective and cost-effective. Perseus was used to generate the questionnaire, which was linked to the prototype built using MS Word uploaded on the server for users to access. The results were automatically sent to the experimenter and pcAnywhere was used to obtain the results that were stored on the server. The entire method was very simple and worked smoothly in spite of the experimenter being in a different state than the server. The technique can be easily used by researchers and information designers to obtain user feedback on their designs.

The Java script that was used to record the system clock at each click of a hyperlink on the prototype (Appendix C) is a valuable contribution of the study. It can be used in remote prototype testing where user performance measures like time are being recorded. Since it names the link corresponding to each time stamp, it also acts as a log of the sequence of clicks that the user performs and can be used by the experimenter to evaluate errors in task performance as well. The above form of time-stamping allows the experimenter to have control over time-recording rather than the user. The fact that the user has control is a disadvantage of remote testing compared to traditional laboratory testing.

The three metrics used to determine user acceptance of the portals were derived from theories of human-computer interaction. The metrics thus have a strong theoretical foundation and may be used by Web portal designers to compare alternative information presentation styles.

CHAPTER 6. LIMITATIONS

The portal used in the study was a vertical portal containing information about a specific category, namely, academics. The user class involved in the study was undergraduate students. The results and outcome of the study are thus specific to the effects of applying the theories of Information Foraging and Information Scent to an academic portal and testing the designs on undergraduate students. So the study tested the effects of tailoring the order of main categories and descriptions to user preference on an academic portal. The application of the same theories may yield different results with other forms of portals like horizontal portals or portals that are not text-based. The effects may be different with other information categories like entertainment, weather, shopping and so on. The theories could yield different effects on other types of information layout and presentation such as portals with graphics or other sound and visual effects and information cues. It was beyond the scope of the study to compare the effects of the theories on different kinds of portals and information categories but it could be an avenue for future research in the area.

CHAPTER 7. FUTURE RESEARCH

An avenue for future research could be a simplification of the remote data collection and prototype testing technique that was used in the study. Further empirical testing and validation of the technique could be done by comparing the remote technique to a traditional laboratory testing technique. The process could be valuable to website designers working on a limited budget since it is highly cost-effective and time-effective.

Another opportunity for further research could be the development of process recommendations for information design for other important and widely used portals like what was done for the text-based academic information portal in this study. Other types of portals like horizontal portals or portals with graphics or portals containing information on other topics like news, entertainment, shopping and so on, can be subjected to the information design effects as was done in this study for an academic information portal. The study revealed that the application of Information Foraging theory (tailoring of main categories of information to user preference) to the academic portal significantly decreased information location time but had no effect on user ratings and acceptance or errors. The study also revealed that Information Scent had no effect on user acceptance or user performance. But the application of the above theories could yield different results with other types of portals and that is an avenue for further research that should be explored. The results of such research done in the future could be integrated with the results of this study to obtain a clearer idea of the effects of the theories. The reason for the above is that the theories of Information Foraging and Information Scent were implemented with respect to portal design and tested on users for the first time in this study. Further research in the area will prove very valuable in providing more empirical evidence of the effects of the theories.

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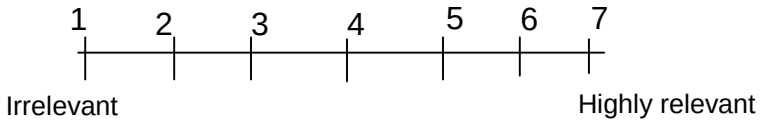
APPENDIX A

Requirements Gathering Questionnaire

Please open the Web page http://www.vt.edu/2000/academics. You may need to refer to that page while answering this survey questionnaire, so keep the Web page open in another window.

PART 1

Please rate the following categories of information (which are displayed on the above web page) according to how relevant you think each one of them is, to you as an undergraduate student. Use this scale for the ratings:



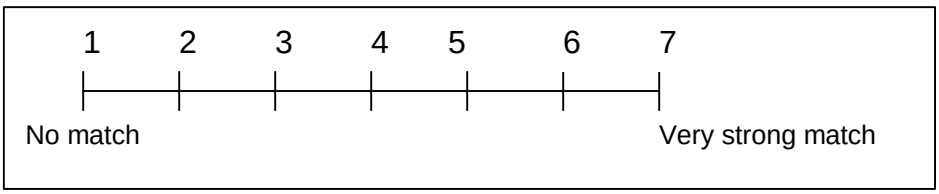
Type the ratings in the column that says 'Relevance'.
Also give a ranking to these categories in order of preference (your preference for seeing the categories on the academics Web page), from 1 to 19. Assign a rank of 1 to the most preferred category and so on. Please do not assign the same rank to two or more categories.

In case it is not clear to you what a category in the list below means, then go to the web page given above and explore that category to see what content it has. Then come back to this list and rate and rank it.

Type the rankings in the column that says 'Preference'.

Category of information	Relevance	Preference
Colleges and departments		
Classes, catalogs, Courses, Exams		
University Core Curriculum		
Commencement information		
Libraries		
Academic Programs and Support		
Continuing Education		
Hokie SPA		
CourseInfo Student Page		
Distance and Distributed Learning		
The Electronic Campus of Virginia (E-CVA)		
Fees, Tuition and other Information		
Graduate School		
Guide to Majors		
University Office of International Programs		
Office of the university Registrar		
Virginia Tech Online		
Extended Campus Programs		
Summer Sessions Info		

For each of the above categories a list of relevant keywords is given below. Please rate the keywords and rank them. Please rate each keyword according to how closely you think it matches the category.
Use this scale for rating:



Please type your ratings in the column that says ‘Relevance’ and type your rankings in the column that says ‘Preference’. If you would like to add other keywords that you think are relevant but are not included in the list, please add them in the spaces provided at the bottom of each table. You can add up to three such keywords. Please rate and rank them too along with the words already in the list.

1. Colleges and Departments

Keyword	**Relevance**	**Preference**
Overview of the college		
Academic affairs		
Departments		
Admissions		
International programs		
Scholarships		
Research		
News about the college		

2. Classes, Catalogs, Courses, Exams

Keyword	Relevance	Preference
Academic calendar		
Class timetables		
Exam schedules		
Office of the University Registrar		
Online Course information and Materials		

3. University Core Curriculum

Keyword	Relevance	Preference
Curriculum goals		
Writing and Discourse		
Ideas, Cultural Traditions and Values		
Society and Human Behavior		
Scientific Reasoning and Discovery		
Writing intensive courses		
Core Curriculum Worksheet		

4. Spring commencement information

Keyword	Relevance	Preference
Dates		
Locations		
Guests seating		
Parking		

5. Academic Programs and Support

Keyword	Relevance	Preference
Academic Assessment		
Career Services		
Center for Academic Enrichment and Excellence		
Honor System		
Virginia Tech Learning Centers		
Writing Center		
Counseling Centers		

6. Libraries

Keyword	Relevance	Preference
Addison		
Journal database		
Electronic Reference Shelf		
Virtual Tour		
How to do Library Research		
Reserve Resources		

7. Continuing Education

Keyword	Relevance	Preference
Research and scholarships		
Facilities		
Course catalog		
Newsletter		
Off campus programs		

8. Hokie SPA

Keyword	Relevance	Preference
Student accounts		
Registration information		
Student status		

9. CourseInfo Student Page

Keyword	Relevance	Preference
Course Listings		
Course Information		

10. Distance and Distributed learning

Keyword	Relevance	Preference
Courses offered		
Degrees		
Student support		
Calendar		

11. Electronic Campus of Virginia

Keyword	Relevance	Preference
Courses		
Degrees		
Calendar		
Student Support		

12. Fees, Tuition and Other information

Keyword	Relevance	Preference
Tuition and Fees		
Student refunds		
Budget Tuition		
Deadlines		
Direct Deposit		

13. Graduate School

Keyword	Relevance	Preference
Applications		
Funding		
Support		
Policies		

14. Guide to Majors

Keyword	Relevance	Preference
Specializations		
Employment outlook		

15. Office of the University Registrar

Keyword	Relevance	Preference
Academic calendar		
Transcripts		
Class timetables		
Holidays		
Exam Schedule		

16. Virginia Tech Online

Keyword	Relevance	Preference
Courses		
Enrolment		

17. Extended Campus Programs

Keyword	Relevance	Preference
Centers		
Enrolment		

18. Summer Sessions Info

Keyword	Relevance	Preference
Timetable of classes		
Registration		
Tuition and fees		
Exam Schedule		

Thank You!

APPENDIX B

IRB application

Title: Application of Human-computer Interaction Theories to Information Design on Internet Portals
Principal investigator: Sushma Rao, Dr. Tonya L. Smith-Jackson

Justification of project

University Web sites are fast becoming a primary source of information for students, potential students, faculty and staff. Due to its varied user classes, the information on the web site is also varied. An example is the academic information portal that contains some information that is relevant to graduate students, some that is relevant to undergraduate students, and some to both.
The aim of this study is to determine if an alternative design for this portal that contains information relevant to only one of these user classes and is designed with the application of HCI theories (tailored presentation style) may be easier to use than the existing composite design.
An online comparison of presentation styles will be conducted for this purpose.

Method

Requirements gathering (Study 1):

Participants:
For this phase of the study, 10 undergraduate students will be recruited from the Virginia Tech student community. They will be recruited with the help of faculty members and/or department staff, through e-mails posted on departmental Listservs.

Purpose:
The purpose of this phase is to gather user preferences for academic topics and also their preference for keywords describing each category. The results of Study 1 will be used as a basis for designing the tailored prototypes for Study 2.

Procedure:
The participant will be sent an informed consent form via e-mail. Once it is signed (indicated by typing name onto the form) by the participant and returned, he/she will be sent the requirements gathering questionnaire once again via e-mail. The participant will

be asked to open the "Academics" information portal and answer the questionnaire with reference to it. He/she will then be asked to send the completed questionnaire back. Subsequently, the compensation amount for participation will be sent to the participant.

Prototype Testing (Study 2):

Participants:
For this phase, 40 undergraduate students from the Virginia Tech student community will be recruited with the help of faculty members and/or department staff.

Purpose:
The purpose of this phase is to collect data that will be used to compare the existing and tailored Web portal presentation styles.

Procedure:
The participants will be asked to access a Web site on which the prototypes will be uploaded. A list of tasks will be included. After performing a task they will be required to rate ease of use and quality of information cues on four scales that will be provided.

Risks and Benefits

There are no physical or emotional risks associated with this project.

Compensation
Each participant will be given 7 dollars as compensation for their participation. Their participation will contribute to a determination of the ideal presentation style to use for displaying information for students on the Virginia Tech Web site and possibly other university Web portals.

Informed Consent:

See attached sheet.

Biographical Sketch:

Sushma Rao is a Masters' student in the Department of Industrial and Systems Engineering, Human Factors option. She has completed four semesters towards her Masters' degree at Virginia Tech. This project will be conducted towards the completion of her Masters thesis.

Dr. Tonya Smith-Jackson is an Assistant Professor of Human Factors Engineering at Virginia Tech. Her teaching interests include Cognitive Ergonomics, User Interface

Design for Disadvantaged Users, Safety and Compliance. She is Director of the Assessment and Cognitive Ergonomics Laboratory.

INFORMED CONSENT FOR STUDY 1

Title of the project: Application of Human-computer Interaction Theories to Information Design on Internet Portals
Principal Investigator: Sushma Rao and Dr. Tonya L. Smith-Jackson.

Purpose of the project:
The purpose of this project is to compare the ease of use of four presentation styles for an academic information portal.

Information:

As the participant you will be required to visit a Web page that will be specified in the instructions and answer questions related to it. You will be asked to rate certain aspects of the displayed information on a scale that will also be provided with the instructions. The entire process should take less than an hour. The purpose of this procedure is NOT to evaluate YOUR skills, but to evaluate the how well the Web page design meets your needs.

Risks:
No physical or emotional risks are associated with this project

Compensation:

On completion of the tasks, you will be paid 7 dollars as compensation for your participation in the project. In addition, you will be provided with contact information that you may use, to find out about the results of the study.

Confidentiality:
The information obtained in this research will be kept strictly confidential. At no time will the results of the study be released to anyone other than the researchers without your written consent.
You will be identified by a 3-digit study code. Data will be securely stored and only made available in the context of research publications and discussion. No reference will be made in oral or written reports that could link you to the data. You will not be identified as a participant in the study at any time.

Freedom to withdraw:
You are free to withdraw at any time from the study without penalty.

Participant's responsibilities:
It is very important that you keep your activities and information discussed with respect to this project strictly confidential since others will be participating in this study.

Questions:
If you have any questions or there is any part of this form that you do not understand, please feel free to ask now. You may send your questions to:

David M. Moore
540-231-4991/moored@vt.edu
Chair, IRB
Office of Research Compliance
Research & Graduate Studies

Participant's permission:
I have read and understand the Informed Consent and conditions of this project. I have had all questions answered. I hereby acknowledge the above and give my voluntary consent for participation in this project.

If I participate, I may withdraw at any time without penalty.

Signature: _____

Date: _____

APPENDIX C

Explanation of the time-stamping process:

When the user clicks on the URL provided to access the survey, a page opens, with a space for them to enter their participant code (See Appendix F). When they enter the code and click the <Submit> button on the page, a Perl script (uploaded on the server beforehand) creates a text (.txt) file in the directory TimeStamp*.txt where * is 1,2,3 or 4 depending on which prototype it is for. The Perl script also records, in the file mentioned above, which user is accessing the survey. The Perl script is included below. Subsequently, as the user clicks on a hyperlink on the prototype, the time is recorded in this .txt file under his/her participant code. TimeStamp*.txt was created on the server beforehand. The script also displays the next html page to the user, containing a button "Continue to survey", which when clicked, takes the user to the html page with the survey and prototype.

```
/* Filecreate.pl */

#!/usr/local/bin/perl5 –w

#This is a simple Perl implementation of a post-query function.
read(STDIN,$namevalues,$ENV{'CONTENT_LENGTH'});
@namevalue = split(/&/,$namevalues);
($name,$value) = split(/=/,$namevalue[0]);

#create  a file and store the value variable.
open(out_handle,">>../TimeStamp/TimeStamp1.txt");
print out_handle "Time Stamp results for User Code $value\n";
close(out_handle);

#The following code prints out the header of the HTML file that the viewer
#is going to be looking at. This is output that will be on the screen.

$http_header= <<XXX;
Content-Type: text/html
<html>
<head>
<title>Continue to Survey..</title>
</head>
<body lang="EN-US" link="blue" vlink="purple" style="tab-interval:.5in">
<p> </p>  <p> </p>
<palign="center"><a
href="http://ace.ise.vt.edu/onlinesurvey/Srao/SM_Interface1_TS/Interface1test_page.htm
">Continue to Survey </a> </p>
</body>
```

```
</html>
XXX
print $http_header;
#the end of the HTML document.

/* End Filecreate.pl */
```

In the above code, the line
open(out_handle,">>../TimeStamp/TimeStamp1.txt");
opens the file TimeStamp1.txt in the subdirectory TimeStamp.
The line
print out_handle "Time Stamp results for User Code $value\n";
makes an entry in the file TimeStamp1.txt for that particular user.

When the user begins performing the tasks, he/she clicks on hyperlinks on the prototype and the time (hour, minute and second) at each click is recorded in the appropriate subdirectory. The following Java script that is embedded in the source code of the prototype/survey page, is called each time a user clicks on a hyperlink. The Java script records and passes on the time and link number to a Perl file on the server.

```
<script language="Javascript”>

function f1(i)
{

// Create a date object.
var d = new Date();

// Get the hours, minutes and seconds from the date object.
var hh = d.getHours();
var mi = d.getMinutes();
var ss = d.getSeconds();
  var hreftag = '/msw/cgi-bin/SM_I1L'+i+'.pl';

// Concatenate all the values and form the timestamp.
var stime = hh + ':' + mi + ':' + ss;

//Move to satellite page
location.href = hreftag+'?tt=' + stime+'&fnumber='+ i;
}

</script>
```

The Perl script that is accessed is detailed below. This is the script that is accessed when a user clicks on the first hyperlink on Interface 1.

```
#!usr/local/bin/perl5 -w
use CGI;
$q = new CGI();
$tt = $q->param('tt'); **extracts the timeand link number**
$pgno = $q->param('fnumber');
#print $tt;
#print $pgno;
$yourdir = "TimeStamp";
open(out_MaintoSat,">>../TimeStamp/TimeStamp1.txt");
print out_MaintoSat "Click on link $pgno at time $tt\n"; **puts information in file**
close(out_MaintoSat);

$http_header = <<XXX;
<html>
<head>
<title> SM_I1L1 </title>
</head>
<body lang=EN-US link=blue vlink=purple style='tab-interval:.5in'>
  <p> </p>  <p> </p>
<p align="center"> C5-O </p>
<p class=MsoNormal align=center style='text-align:center'><a
href="SM_Interface1_Main.htm">Back to main page</a></p>
</body>
</html>
XXX
print $http_header;
__END__
```

In the above script, the lines
$tt = $q->param('tt');
$pgno = $q->param('fnumber');

extract the time and link number (hyperlink the user clicked on)
The line
open(out_MaintoSat,">>../TimeStamp/TimeStamp1.txt")
opens the file for that user, which was created when he/she entered the user code to access the survey in the beginning.
The line
print out_MaintoSat "Click on link $pgno at time $tt\n";
stores the time-stamp and link number in the file.
Finally the script displays the satellite page to the user.

The following is a time-stamp file that was created for a user of Interface 1:
Time Stamp results for User Code CDough1
Click on link 4 at time 15:58:11

Click on link 6 at time 15:59:35
Click on link 2 at time 16:0:23
Click on link 7 at time 16:1:37
Click on link 1 at time 16:2:42
Click on link 1 at time 16:3:26
Click on link 16 at time 16:4:0
Click on link 9 at time 16:4:46
Click on link 2 at time 16:5:17
Click on link 12 at time 16:6:5
Click on link 14 at time 16:6:38
Click on link 9 at time 16:7:23
Click on link 11 at time 16:8:6
Click on link 6 at time 16:8:39
Click on link 2 at time 16:9:12
Click on link 5 at time 16:9:49

The time taken for each task by each user was recorded and analyzed.

APPENDIX D

Survey questionnaire for the Control Interface, which was created using Perseus:

Questionnaire

Instructions

Thank you for agreeing to participate in this study.

The top frame on your screen contains the test Website and this bottom frame contains the questionnaire.

You may have to scroll up/down to see each frame entirely from top to bottom (Use the scrollbar on the right of your screen).

The questionnaire in this frame contains 16 tasks. Each task asks you to locate a piece of information in the Website above. After performing the first task you have to come back to this questionnaire frame and answer a few questions about the task you just performed. Then you move on to the next task repeat the same process.

It will take less than one hour to complete the entire questionnaire.

Important: Please make sure that you browse the above Website according to the exact instructions provided in each task in the questionnaire. Also, it is important that you complete this survey in a single sitting without taking a break from it anytime in the middle.

Below is the Informed consent form. Please read it and type in your name and the date etc at the end. Once you have done that you can move on to the tasks.

Informed Consent:

Title of the project: Application of Human-computer Interaction Theories to Information Design on Internet Portals

Principal Investigator: Sushma Rao and Dr. Tonya L. Smith-Jackson.

Purpose of the project:

The purpose of this project is to compare the ease of use of four presentation styles for an academic information portal.

Information:

As the participant you will be required to visit a Web page and perform some information location tasks that will be provided in a questionnaire. After performing each task, you

will be asked to rate certain aspects of the displayed information on four scales that will also be provided with the instructions. The entire process should take less than an hour. The purpose of this procedure is NOT to evaluate YOUR skills, but to evaluate how well the Web page design meets your needs.

Risks:

No physical or emotional risks are associated with this project.

Compensation:

On completion of the tasks, you will be paid 7 dollars as compensation for your participation in the project. In addition, you will be provided with contact information that you may use, to find out about the results of the study.

Confidentiality:

The information obtained in this research will be kept strictly confidential. At no time will the results of the study be released to anyone other than the researchers without your written consent.

You will be identified by a 3-digit study code. Data will be securely stored and only made available in the context of research publications and discussion. No reference will be made in oral or written reports that could link you to the data. You will not be identified as a participant in the study at any time.

Freedom to withdraw:

You are free to withdraw at any time from the study without penalty.

Participant responsibilities:

It is very important that you keep your activities and information discussed with respect to this project strictly confidential since others will be participating in this study.

If you have any questions or there is any part of this form that you do not understand, please feel free to ask now. You may send your questions to: David M.Moore (moored@vt.edu), IRB Chair, Office of Research Compliance, Research and Graduate Studies.

Participant permission:

I have read and understand the Informed Consent and conditions of this project. I have had all questions answered. I hereby acknowledge the above and give my voluntary consent for participation in this project.

If I participate, I may withdraw at any time without penalty.

Please enter your name and the date below:

Name

Date

Please enter your SSN and your full postal address below (the payment for your participation will be sent to this address when you complete the survey) :

SSN:

Address:

Instructions:

Before you begin the tasks, please note: The phrases that are in color in the above Website are "links". What is written in black italics next to each link, is a "description", which tells you more about the link. While performing each task, please be sure to read both the link and the description next to it.

Please enter the time displayed on your computer (bottom right part of your screen).

Task 1:

You are attending the graduation ceremony at your university and need to find out where it is being held. Click on the link in the above Website that you think will take you to this information.

IMPORTANT: When you click on a link in the above Website, you will see a page with a code (a set of alphabets and numbers) and a link saying "Back to main page". Please come back to this questionnaire and enter the code exactly, in the first question for Task 1, below. Then go back to the above frame and click on "Back to main page". After that, come back to this questionnaire and answer the remaining questions for Task 1. Once you have done that read Task 2 and carry out the same process.

Please keep these instructions in mind for all 16 tasks. You may now go to the Website above to carry out Task 1.

Based on the task you just performed, answer the following questions about the Website:

Please enter the code from the above frame.

Code

How easy was it to decide which link would take you to the desired information?

- 1 (Extremely easy)
- 2
- 3
- 4
- 5
- 6
- 7(Extremely difficult)

What amount of information did you feel you had to browse through while deciding which link to click on?

- 1 (Very large amount)
- 2
- 3
- 4
- 5
- 6
- 7 (Very small amount)

How helpful or intuitive were the descriptions (black, italics) in telling you what each link (in color, underlined) was about?

- 1 (Not intuitive)
- 2
- 3
- 4
- 5
- 6
- 7 (Very intuitive)

Task 2:

You are interested in a particular course but have just discovered that it is not offered in your university. However, your advisor tells you that it is offered in another college in the same state. You want to find out if this is so and how to enroll for this course. Click on the link that will provide this information for you.

Based on the task you just performed, answer the following questions about the Website:

Please enter the code from the above frame.

Code

How easy was it to to decide which link would take you to the desired information?

- 1 (Extremely easy)
- 2
- 3
- 4
- 5
- 6
- 7(Extremely difficult)

What amount of information did you feel you had to browse through while trying to decide which link to click on?

- ☐ 1 (Very large amount)
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7 (Very small amount)

How helpful or intuitive were the descriptions (black, italics) in telling you what each link (in color, underlined) was about?

- ☐ 1 (Not intuitive)
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7(Very intuitive)

Task 3:

You are interested in taking a course but it is not being offered in the university center where you are studying. You want to find out if it is being offered in another center of the same university. Click on the link that will take you to this information.

Based on the task you just performed, answer the following questions about the Website:

Please enter the code from the above frame.

Code ☐

How easy was it to decide which link would take you to the desired information?

- ☐ 1 (Extremely easy)
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

- 6
- 7(Extremely difficult)

What amount of information did you feel you had to browse through while trying to decide which link to click on?

- 1 (Very large amount)
- 2
- 3
- 4
- 5
- 6
- 7 (Very small amount)

How helpful or intuitive were the descriptions (black, italics) in telling you what each link (in color, underlined) was about?

- 1 (Not intuitive)
- 2
- 3
- 4
- 5
- 6
- 7 (Very intuitive)

Task 4:

You need to find out if the university has put any financial holds on your student account. Click on the link that will take you to this information.

Based on the task you just performed, answer the following questions about the Website:

Please enter the code from the above frame.

Code

How easy was it to decide which link would take you to the desired information?

- 1 (Extremely easy)
- 2
- 3
- 4

- 5
- 6
- 7(Extremely difficult)

What amount of information did you feel you had to browse through while deciding which link to click on?

- 1 (Very large amount)
- 2
- 3
- 4
- 5
- 6
- 7 (Very small amount)

How helpful or intuitive were the descriptions (black, italics) in telling you what each link (in color, underlined) was about?

- 1 (Not intuitive)
- 2
- 3
- 4
- 5
- 6
- 7 (Very intuitive)

Task 5:

Your GPA has fallen below the minimum required and you are looking for information on who can help you out of this situation by advising you: Click on the link that will take you to this information.

Based on the task you just performed, answer the following questions about the Website:

Please enter the code from the above frame.

Code

How easy was it to decide which link would take you to the desired information?

- 1 (Extremely easy)
- 2

- 3
- 4
- 5
- 6
- 7(Extremely difficult)

What amount of information did you feel you had to browse through while deciding which link to click on?

- 1 (Very large amount)
- 2
- 3
- 4
- 5
- 6
- 7 (Very small amount)

How helpful or intuitive were the descriptions (black, italics) in telling you what each link (in color, underlined) was about?

- 1 (Not intuitive)
- 2
- 3
- 4
- 5
- 6
- 7 (Very intuitive)

Task 6:

You need to decide which field to major in as part of your undergraduate studies. To do so you want to look at all the majors offered by the university and details about each. Click on the link that will take you to this information.

Based on the task you just performed, answer the following questions about the Website:

Please enter the code from the above frame.

Code

How easy was it to decide which link would take you to the desired information?

- ☐ 1 (Extremely easy)
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7(Extremely difficult)

What amount of information did you feel you had to browse through while deciding which link to click on?

- ☐ 1 (Very large amount)
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7 (Very small amount)

How helpful or intuitive were the descriptions (black, italics) in telling you what each link (in color, underlined) was about?

- ☐ 1 (Not intuitive)
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7 (Very intuitive)

Task 7:

You are staying in school during the summer break and wish to find out what courses are being offered during that session. Select the link that will take you to this information.

Based on the task you just performed, answer the following questions about the Website:

Please enter the code from the above frame.

Code [ ]

How easy was it to decide which link would take you to the desired information?

- 1 (Extremely easy)
- 2
- 3
- 4
- 5
- 6
- 7(Extremely difficult)

What amount of information did you feel you had to browse through while performing the task?

- 1 (Very large amount)
- 2
- 3
- 4
- 5
- 6
- 7 (Very small amount)

How helpful or intuitive were the descriptions (black, italics) in telling you what each link (in color, underlined) was about?

- 1 (Not intuitive)
- 2
- 3
- 4
- 5
- 6
- 7 (Very intuitive)

Task 8:

You are going home for a semester but would like to take a course from your university over the Internet. So you would like to find out what on-line courses are being offered. Click on the link that will lead you to this information.

Based on the task you just performed, answer the following questions about the Website:

Please enter the code from the above frame.

Code

How easy was it to decide which link would take you to the desired information?

- 1 (Extremely easy)
- 2
- 3
- 4
- 5
- 6
- 7(Extremely difficult)

What amount of information did you feel you had to browse through while deciding which link to click on?

- 1 (Very large amount)
- 2
- 3
- 4
- 5
- 6
- 7 (Very small amount)

How helpful or intuitive were the descriptions (black, italics) in telling you what each link (in color, underlined) was about?

- 1 (Not intuitive)
- 2
- 3
- 4
- 5
- 6
- 7 (Very intuitive)

Task 9:

You have an appointment with your advisor to discuss what courses you should take as part of your undergraduate program. In preparation for the meeting your advisor has asked you to make a systematic list of the courses you wish to take and which area of the

curriculum goal each course relates to: Click on the link that will help you prepare this list.

Based on the task you just performed, answer the following questions about the Website:

Please enter the code from the above frame.

Code

How easy was it to decide which link would take you to the desired information?

- 1 (Extremely easy)
- 2
- 3
- 4
- 5
- 6
- 7(Extremely difficult)

What amount of information did you feel you had to browse through while deciding which link to click on?

- 1 (Very large amount)
- 2
- 3
- 4
- 5
- 6
- 7 (Very small amount)

How helpful or intuitive were the descriptions (black, italics) in telling you what each link (in color, underlined) was about?

- 1 (Not intuitive)
- 2
- 3
- 4
- 5
- 6
- 7 (Very intuitive)

Task 10:

You plan to apply for admission to a graduate program at your university after completing your undergraduate studies. You need to find out the application procedure. Click on the link that will help you find this information.

Based on the task you just performed, answer the following questions about the Website:

Please enter the code from the above frame.

Code

How easy was it to decide which link would take you to the desired information?

- 1 (Extremely easy)
- 2
- 3
- 4
- 5
- 6
- 7(Extremely difficult)

What amount of information did you feel you had to browse through while deciding which link to click on?

- 1 (Very large amount)
- 2
- 3
- 4
- 5
- 6
- 7 (Very small amount)

How helpful or intuitive were the descriptions (black, italics) in telling you what each link (in color, underlined) was about?

- 1 (Not intuitive)
- 2
- 3
- 4
- 5

- 6
- 7 (Very intuitive)

Task 11:

You want to apply for an internship for the summer and to do so you need to order a document showing your grades for the previous semester. So you want to find out the procedure for ordering it. Click on the link that will provide you with the information you need.

Based on the task you just performed, answer the following questions about the Website:

Please enter the code from the above frame.

Code

How easy was it to decide which link would take you to the desired information?

- 1 (Extremely easy)
- 2
- 3
- 4
- 5
- 6
- 7(Extremely difficult)

What amount of information did you feel you had to browse through while deciding which link to click on?

- 1 (Very large amount)
- 2
- 3
- 4
- 5
- 6
- 7 (Very small amount)

How helpful or intuitive were the descriptions (black, italics) in telling you what each link (in color, underlined) was about?

- 1 (Not intuitive)
- 2

- 3
- 4
- 5
- 6
- 7 (Very intuitive)

Task 12:

Your professor wants your class to complete a reading assignment and has announced that the details of the assignment may be found on the Web page for the course. Click on the link that will lead you to this information.

Based on the task you just performed, answer the following questions about the Website:

Please enter the code from the frame above.

Code

How easy was it to decide which link would take you to the desireed information?

- 1 (Extremely easy)
- 2
- 3
- 4
- 5
- 6
- 7(Extremely difficult)

What amount of information did you feel you had to browse through while deciding which link to click on?

- 1 (Very large amount)
- 2
- 3
- 4
- 5
- 6
- 7 (Very small amount)

How helpful or intuitive were the descriptions (black, italics) in telling you what each link (in color, underlined) was about?

- ☐ 1 (Not intuitive)
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7 (Very intuitive)

Task 13:

You need to find out the tuition fee for the following semester. Click on the link that will give you this information.

Based on the task you just performed, answer the following questions about the Website:

Please enter the code from the above frame

Code [ ]

How easy was it to decide which link would take you to the desired information?

- ☐ 1 (Extremely easy)
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7(Extremely difficult)

What amount of information did you feel you had to browse through while deciding which link to click on?

- ☐ 1 (Very large amount)
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7 (Very small amount)

How helpful or intuitive were the descriptions (black, italics) in telling you what each link (in color, underlined) was about?

- 1 (Not intuitive)
- 2
- 3
- 4
- 5
- 6
- 7 (Very intuitive)

Task 14:

You would like to get information on current employment opportunities for students with your degree. Click on the link that will help you find this information.

Based on the task you just performed, answer the following questions about the Website:

Please enter the code from the above frame.

Code

How easy was it to decide which link would take you to the desired information?

- 1 (Extremely easy)
- 2
- 3
- 4
- 5
- 6
- 7(Extremely difficult)

What amount of information did you feel you had to browse through while deciding which link to click on?

- 1 (Very large amount)
- 2
- 3
- 4
- 5

- 6
- 7 (Very small amount)

How helpful or intuitive were the descriptions (black, italics) in telling you what each link (in color, underlined) was about?

- 1 (Not intuitive)
- 2
- 3
- 4
- 5
- 6
- 7 (Very intuitive)

Task 15:

You want to add a course you have heard about from your classmates, but need to first check if its timing conflicts with any of your current courses: Click on the link that will lead you to this information.

Based on the task you just performed, answer the following questions about the Website:

Please enter the code from the above frame.

Code

How easy was it to decide which link would take you to the desired information?

- 1 (Extremely easy)
- 2
- 3
- 4
- 5
- 6
- 7(Extremely difficult)

What amount of information did you feel you had to browse through while deciding which link to click on?

- 1 (Very large amount)
- 2
- 3

- 4
- 5
- 6
- 7 (Very small amount)

How helpful or intuitive were the descriptions (black, italics) in telling you what each link (in color, underlined) was about?

- 1 (Not intuitive)
- 2
- 3
- 4
- 5
- 6
- 7 (Very intuitive)

Task 16:

You need to find out if a particular book you need for your assignment is currently available in the library or if all copies have been issued. Click on the link that will provide you with this information.

Based on the task you just performed, answer the following questions about the Website:

Please enter the code from the above frame.

Code

How easy was it to decide which link would take you to the desired information?

- 1 (Extremely easy)
- 2
- 3
- 4
- 5
- 6
- 7(Extremely difficult)

What amount of information did you feel you had to browse through while deciding which link to click on?

- 1 (Very large amount)
- 2
- 3
- 4
- 5
- 6
- 7 (Very small amount)

How helpful or intuitive were the descriptions (black, italics) in telling you what each link (in color, underlined) was about?

- 1 (Not intuitive)
- 2
- 3
- 4
- 5
- 6
- 7 (Very intuitive)

Please enter the time displayed on your computer (Bottom right part of your screen).

I appreciate your taking the time to participate in this study. Please make sure that you have filled in your name, SSN and full postal address at the top of the questionnaire. When you click on the <Submit> button below, your survey will be recived automatically by me and I will send you the $7 payment check immediately. Please allow 4-5 days time for the check to reach you. Thank you very much.

Sushma Rao.

Submit Survey

APPENDIX E

ANOVA tables

1) ANOVA table for the dependent variable time

Class	Levels	Values
main	2	1 2
descrip	2	1 2

Number of observations 40

Dependent Variable: totaltime

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	256570.875	85523.625	2.22	0.1024
Error	36	1385991.100	38499.753		
Corrected Total	39	1642561.975			

R-Square	Coeff Var	Root MSE	totaltime Mean
0.156202	24.26959	196.2135	808.4750

Source	DF	Type I SS	Mean Square	F Value	Pr > F
main	1	170433.0250	170433.0250	4.43	0.0424
descrip	1	4687.2250	4687.2250	0.12	0.7292
main*descrip	1	81450.6250	81450.6250	2.12	0.1545

Source	DF	Type III SS	Mean Square	F Value	Pr > F
main	1	170433.0250	170433.0250	4.43	0.0424
descrip	1	4687.2250	4687.2250	0.12	0.7292
main*descrip	1	81450.6250	81450.6250	2.12	0.1545

Least Squares Means

main	totaltime LSMEAN	H0:LSMean1= LSMean2 Pr > |t|
1	873.750000	0.0424
2	743.200000	

descrip	totaltime LSMEAN	H0:LSMean1= LSMean2 Pr > |t|
1	797.650000	0.7292
2	819.300000	

main	descrip	totaltime LSMEAN	LSMEAN Number
1	1	817.800000	1
1	2	929.700000	2
2	1	777.500000	3
2	2	708.900000	4

Least Squares Means

Least Squares Means for effect main*descrip
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: totaltime

i/j	1	2	3	4

1		0.2104	0.6488	0.2226
2	0.2104		0.0914	0.0165
3	0.6488	0.0914		0.4395
4	0.2226	0.0165	0.4395	

2) ANOVA table for the dependent variable ease of access:

Class Level Information

Class	Levels	Values
main	2	1 2
descrip	2	1 2

Number of observations 40

Dependent Variable: totalaccess

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1320.800000	440.266667	6.35	0.0014
Error	36	2495.600000	69.322222		
Corrected Total	39	3816.400000			

R-Square	Coeff Var	Root MSE	totalaccess Mean
0.346085	21.73889	8.325997	38.30000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
main	1	19.600000	19.600000	0.28	0.5982
descrip	1	1.600000	1.600000	0.02	0.8801
main*descrip	1	1299.600000	1299.600000	18.75	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
main	1	19.600000	19.600000	0.28	0.5982

descrip	1	1.600000	0.02	0.8801
main*descrip	1	1299.600000	18.75	0.0001

Least Squares Means

main	LSMEAN	H0:LSMean1= LSMean2 Pr > |t|
1	39.0000000	0.5982
2	37.6000000	

totalaccess

descrip	LSMEAN	H0:LSMean1= LSMean2 Pr > |t|
1	38.5000000	0.8801
2	38.1000000	

totalaccess

main	descrip	LSMEAN	LSMEAN Number
1	1	44.9000000	1
1	2	33.1000000	2
2	1	32.1000000	3
2	2	43.1000000	4

Least Squares Means

Least Squares Means for effect main*descrip
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: totalaccess

i/j	1	2	3	4
1		0.0031	0.0015	0.6317
2	0.0031		0.7898	0.0109
3	0.0015	0.7898		0.0055
4	0.6317	0.0109	0.0055	

3) ANOVA table for dependent variable intuitiveness of descriptions:

Class Level Information

Class	Levels	Values
main	2	1 2
descrip	2	1 2

Number of observations 40

Dependent Variable: totaldescrip

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1429.000000	476.333333	5.39	0.0036
Error	36	3182.600000	88.405556		
Corrected Total	39	4611.600000			

R-Square	Coeff Var	Root MSE	totaldescrip Mean
0.309871	11.38308	9.402423	82.60000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
main	1	22.500000	22.500000	0.25	0.6170
descrip	1	240.100000	240.100000	2.72	0.1081
main*descrip	1	1166.400000	1166.400000	13.19	0.0009

Source	DF	Type III SS	Mean Square	F Value	Pr > F
main	1	22.500000	22.500000	0.25	0.6170
descrip	1	240.100000	240.100000	2.72	0.1081
main*descrip	1	1166.400000	1166.400000	13.19	0.0009

Least Squares Means

main	totaldescrip LSMEAN	H0:LSMean1= LSMean2 Pr > |t|
1	81.8500000	0.6170
2	83.3500000	

descrip	totaldescrip LSMEAN	H0:LSMean1= LSMean2 Pr > |t|
1	85.0500000	0.1081
2	80.1500000	

main	descrip	totaldescrip LSMEAN	LSMEAN Number
1	1	78.9000000	1
1	2	84.8000000	2
2	1	91.2000000	3
2	2	75.5000000	4

Least Squares Means for effect main*descrip
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: totaldescrip

i/j	1	2	3	4
1		0.1691	0.0059	0.4241
2	0.1691		0.1367	0.0334
3	0.0059	0.1367		0.0007
4	0.4241	0.0334	0.0007	

VITA

AREA OF INTEREST
Design and usability evaluation of software and Web interfaces based on user requirements

EDUCATION
Master of Science, **Industrial and Systems Engineering (Human Factors)**, Virginia Tech, *(August '99-July '02)*
Bachelor of Engineering, **Computer Science**, Manipal Institute of Technology, *(November '94-July '99)*

COURSES Usability Engineering, Models, Theories and Frameworks of Human-Computer Interaction, Human Information Processing, Human Factors Research Design, Human Factors System Design, Macro ergonomics, Training System Design, Computer Graphics, Computer Aided Instrumentation and Control, Computer Architecture, Database Management Systems, Artificial Intelligence, Computer Networks, Compiler Construction

TECHNICAL SKILLS *Languages*: C, C++, Perl, HTML, Visual Basic, ColdFusion, JavaScript *Operating Systems*: MS-DOS, Windows, Windows NT *Software Packages*: Perseus, Dreamweaver, SAS, FrontPage, MS Excel, MS Word, MS PowerPoint

EXPERIENCE **Graduate Research Assistant**, Virginia Tech Transportation Institute. Project involved a study on the Conspicuity of Road Signs
Summer Intern, Genesis Finsoft Pvt. Ltd, Bangalore, India. The internship work included the preliminary design of customized databases for medium and large-scale financial companies

PAPERS

- Distance Learning: Current Trends and Human Factors Applications (submitted as part of coursework for Human Information Processing course)
- Remote collection of user feedback on Web portal prototypes (under review)
- Application of human-computer interaction theories to information design on Web portals (under review)

PROJECTS **Link to projects: http://srao0.tripod.com**

- Compared the effects of human-computer interaction theories on information design on Internet portals. Significant findings of research included reduction in information location time on a portal with the application of Information Foraging Theory (M.S thesis)
- Improved the usability of the interface of a web-based email service provided by Virginia Tech to its students and faculty. Research included collection of user requirements and translation into design guidelines (Usability course project)
- Developed a training program to train Usability practitioners in using the User Action Framework Explorer(A usability tool). Development was based on a combination of training system design principles and user requirements (Training Systems Design course project)
- Designed and developed a Parser Tutor with a GUI (using Visual Basic), for a Windows Desktop. The GUI was designed to dynamically generate parse trees and tables to make the experience of learning parse techniques easy for the average computer science student (Senior year of undergraduate course)

HONORS AND AFFILIATIONS **Student member**, Human Factors and Ergonomics Society
Vice President, Organization of Management Skills (1998)