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Spatial and Non-Spatial Metaphors in Interface Design: Navigation, Recall, Recognition, and Perception

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SPATIAL AND NON-SPATIAL METAPHORS IN INTERFACE DESIGN: NAVIGATION, RECALL, RECOGNITION, AND PERCEPTION

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In partial fulfillment of the requirements for the degree Master of Science

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By

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CERTIFICATE OF APPROVAL

MASTER OF SCIENCE THESIS

This is to certify that the Thesis of

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submitted in partial fulfillment of the requirements for the degree of Master of Science in the School of Communications at Ithaca College has been approved.

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ABSTRACT

The purpose of this study was to examine the effect of spatial and non-spatial interface metaphors on user recall, recognition, navigation, and perception. This study was a randomized independent variable mixed methods study that used a convenience sample of thirty participants. In order to assess the effect of spatial and non-spatial metaphors, the researcher designed two websites: one based upon a non-spatial metaphor of an Index and the other based upon a spatial metaphor of the Ithaca College campus. Participants were asked to search for a number of on-campus positions that matched a description they had been given.

Participants' navigation was tracked during the job-searching task. Following the completion of the task, participants were given a short two-part retention test that asked them to first recall and then recognize all positions and duties they had seen. The final part of the experiment involved a short one-one interview with the researcher, which sought to determine the users' perceptions of the interface. Participant's navigation, recall, recognition, and perceptions were examined against information collected at the beginning of the experiment in a short questionnaire about general demographics, computer and internet usage, and previous work experience.

This study demonstrated that there was no significant difference between the spatial and non-spatial metaphors in navigation, user perceptions, or recognition of the information in the interface. A significant difference between the two interfaces was found for the recall of the positions. Significant differences were also found in the task accuracy based upon programming ability, user operating system, and computer and internet use.

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I would also like to thank the numerous participants who volunteered to participate in this study and their many helpful insights. Their participation is the foundation of this study, and without it this thesis could never have been completed.

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DEDICATION

To my fiancé Aaron,
for all of his love and support
in this journey.

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CHAPTER I

INTRODUCTION

During the past several years, the use of e-learning in the United States has dramatically increased. According to a 2003 report by the American Society for Training and Development (ASTD) in 2002, 15.4% of all training in U.S. organizations was delivered using e-learning technologies, compared to only 10.8% in 2001. The growth of e-learning, however, is not limited to the United States. The highest use of e-learning was in Japan, where 20% of training was delivered through technology. E-learning has demonstrated significant growth in today's workplaces and it is necessary to identify and research methods that can increase e-learning effectiveness.

One of the possible ways suggested by researchers and theorists to make e-learning more effective and efficient is the use of metaphors in interface design. According to Marcus (2002), an interface metaphor is a substitute for individual or collective elements that help users enjoy, comprehend, and remember the relationships and entities of computer-based systems. Metaphors are often used in computer interfaces to aid users in navigation and site use (Hamilton, 2000). Previous research has suggested that metaphors improve website navigation and decrease the amount of time it takes for a user to identify the correct link (Padovani & Lansdale, 2003; Suttcliffe, Ennis, & Hu, 2000). Several theorists have suggested that interface metaphors also increase retention and learning, although this hypothesis has not been fully developed or tested (Carroll & Mack, 1985; Laurel, 1993).

Purpose

The purpose of this study was to explore how spatial and non-spatial metaphors in interface design affect users' recall, recognition, navigation, and perceptions. In order to test the impact of these metaphors, the researcher developed a multi-part experiment. This experiment included a short user characteristic survey, a computer-based task, a recall and recognition test, and a one-on-one interview. The participants were asked to fill out a short user characteristic questionnaire that asked several questions about their previous work experience, computer and internet use, as well as basic demographics. Following the questionnaire, participants were asked to complete a computer-based job search using either a spatial or non-spatial metaphoric interface. After completing the job search, they were asked to recall all the positions and the associated duties. Following the recall portion of the retention test, participants were administered a recognition test, which tested their ability to recognize the positions and duties they had observed in the interface. Finally, participants were interviewed about their perceptions of the interface they had used.

Based upon a review of the literature, the researcher hypothesized that participants who used the spatial metaphor interface to complete the on-campus job search would recall and recognize more information about the positions listed and their duties than participants who use the non-spatial metaphor interface. The researcher also hypothesized that participants in the spatial metaphor condition would navigate to the correct information more quickly and with less accidental clicking than subjects who use the non-spatial metaphor interface. A third hypothesis was that participants with less computer experience would find the spatial-metaphor interface more helpful than those with more computer experience; subjects with more computer experience would find the spatial metaphor interface less helpful.

Significance of the Study

With the increasing use of e-learning in both the workplace and educational institutions, the need to develop methods to make learning more effective is paramount. Metaphors have been shown to decrease the time it takes to navigate to a correct link (Kim, 1999; Padovani & Lansdale, 2003). Interface metaphors are also thought to facilitate novice users by allowing them to transfer their previous experience, which may be embodied in the metaphor, to the functionality of the interface (Carroll & Thomas, 1982). If spatial metaphor-based interfaces provide an advantage to novice users over non-spatial interfaces, this could suggest different methods of design based upon user characteristics.

If interface metaphors increase learning, as suggested by much of the literature on metaphor, this finding has far-reaching implications. This study supports this claim about metaphors and learning as it demonstrates that spatial interface metaphors may increase users' recall of information that is displayed spatially. However, this study also demonstrates that users' recognition of information presented in a spatial interface is not greater than users' recognition of information presented in a non-spatial interface. This finding suggests that in certain e-learning applications, spatial metaphors may be helpful if the designer hopes to increase recall, while non-spatial metaphors are as helpful in promoting recognition of information as spatial metaphor interfaces.

One of the goals of e-learning is to make the learning process more efficient and less costly. A major cost associated with any corporate-based training is the cost of the participants' time spent on training (Driscoll, 2002). Several studies have demonstrated that user navigation is more efficient in spatial interfaces compared to non-spatial interfaces (Kim, 1999; Padovani & Lansdale, 2003). However, in many of the studies that demonstrate that navigation is more efficient and less time consuming, participants do not undertake parallel tasks in both interfaces. The differences in the type of task and the inherent difficulty of the task may have influenced the results of previous studies in regard to navigation efficiency. This study contributes to previous research by demonstrating that participants showed no differences in navigational efficiency when they worked with a spatial or non-spatial metaphoric interface to complete a parallel task.

User perceptions are also important in the design of learning applications. A user who is frustrated with an interface is likely to perform poorly on a task. This study examined user perceptions of spatial and non-spatial metaphor interfaces, and determined that the participants interviewed were satisfied with the both spatial and non-spatial interfaces.

A final contribution of this study is that it analyzes several aspects of participants' characteristics and contrasts these with user performance in each of the conditions. One of the most important factors in designing effective metaphor-based interfaces is the careful examination of user characteristics. Previous theory has suggested that user characteristics may effect how useful or easy to use an interface is to a certain population (Erickson, 1990). This study analyzed several aspects of performance including navigation, task accuracy, recall, recognition, and user perceptions, and examined this performance by condition and by several user characteristics. These characteristics included gender, computer experience, application use, internet experience, programming experience, and work experience. Significant differences among these aspects of performance can suggest which type of metaphor, spatial or non-spatial, would be most effective when creating e-learning for particular user populations.

Hypothesizes

The hypotheses for this experiment were as follows:

H1: Participants who use the spatial metaphor interface will recall and recognize more information about the positions listed and their duties than participants who use the non-spatial metaphor interface. Retention and recognition have not been previously addressed by the literature, although many theorists suggest that learning will increase when participants use an interface that is designed around a spatial metaphor. Metaphors, these theorists argue, may increase learning by making memorization easier and allowing users to access previous knowledge (Carroll & Mack, 1985; Laurel, 1993).

H2: Subjects in the spatial metaphor condition will find the correct links more quickly (with less accidental clicking) than subjects who use the non-spatial metaphor condition. Previous studies have suggested that spatial metaphors decrease the retrieval time as well as decrease the number of incorrect links tried when searching for an object (Kim, 1990; Padovani & Lansdale, 2003).

H3: Participants with less computer experience will find the spatial interface more helpful than those with more computer experience; participants with more computer experience will find the metaphor less helpful. Many theorists who study metaphor state that users who are more advanced and have more experience working with computers will find spatial metaphors unhelpful; these metaphors may even interfere with their ability to successfully complete a task (Marx, 1994).

Structure of Study

In this study, participants navigated through an interface to find on-campus student employment positions (student jobs). Participants were randomized into one of two conditions: (1) a spatial metaphor interface that was designed to appear like the Ithaca College campus, and (2) a non-spatial metaphor interface, an index where the links were listed in alphabetical order.

Participant characteristics such as age, nationality, gender, computer and internet use were collected at the beginning of the study through a user characteristic survey. Upon completing the job search, participants were given a short retention test to access their recall and recognition of the information presented in the site, including student positions and the skills and duties required for each position.

Following the retention test, participants were interviewed to determine their perceptions of the interface. Participants' recall and recognition of the information presented in the website were compared in the two conditions in order to determine if differences in performance existed.

A post-hoc analysis of the retention scores, navigation, and perceptions compared any significant differences in performance that occurred due to differences in user characteristics. Participants' previous work experience and their use of the Ithaca College Financial Aid Website job search page were examined to determine if these factors affected the results of the study.

Assumptions and Limitations

This study includes several assumptions that may inhibit its generalizability. These include assumptions about the nature of self-reporting, the effectiveness of the surveys and other research instruments, as well as assumptions about varying levels of computer and internet ability:

- The researcher relied on participants accurately reporting their general characteristics, work history, and usage of various applications.
- The researcher created the surveys and other instruments, including the interview protocol. Previous studies of spatial and non-spatial interfaces did not examine user characteristics or did not use open-ended interview protocols. These surveys were constructed based upon the researcher's investigation of previous research, but the individual surveys and instruments were not previously published or used for similar research.
- Although a vast body of literature states that interface metaphors help novice users effectively use an unfamiliar application, the term "novice" is never defined. This researcher chose to measure several characteristics that could define a novice user, including extent of internet usage, computer usage, programming ability, and application use.
- Finally, the researcher depended on participants fully giving their attention to the experiment and performing to the best of their ability. Since participants were required to compose a short essay on the experiment they undertook in order to receive class credit, it is likely that most students gave the experiment their full attention.

Definitions of Important Terms

Metaphor:

An elemental mechanism of the mind that allows people to apply through comparison what they know from their previous social and physical experiences to other subjects and information (Lakoff & Johnson, 1980).

Interface

A means of interactive computer-mediated communication between a human being and a computer artifact. An interface includes both physical objects and computer systems (both hardware and software, including applications, networks and operating systems) (Marcus, 2002).

Interface Metaphor

A concept that is familiar to an intended set of users that is embodied in the interface of a computer system. The embodiment of a metaphor is intended to reframe or represent a computer's functionality (Yousef, 2001).

Spatial Metaphor

A metaphor that compares the position of objects in space (St. Amant & Dulberg, 1998). An example of a spatial metaphor is a home that illustrates the spatial relationships between rooms. A second example of a spatial metaphor is a map that shows relationships among buildings.

Non-spatial Metaphor

A metaphor that does not compare the position of objects in space, but illustrates non-spatial relationships between objects or beings (Padovani & Lansdale, 2003). An example of a non-spatial metaphor is an index, which illustrates an alphabetic relationship between words.

Cognitive Load

The number and amount of necessary mental resources that are used to complete a task (Kim & Hirtle, 1995).

Mental Models

Hierarchies that conceptually structure and organize data, tasks, roles, and beings in the mind (Marcus, 2002).

Recognition

The least intensive level of memory. It is theorized that recognition, or remembering having viewed an item previously, indicates that piece of information was encoded (Tulving, 1972; Tulving & Thompson, 1973).

Recall

Recall is the most intensive level of memory, and requires the retrieval of encoded information without cues (Lang, 2000).

Virtual Navigation

The process of way finding in a virtual space such as the internet. The term virtual navigation is a spatial metaphor that presents the internet as a spatial area to be navigated, much like a physical space (St. Amant & Dulberg, 1998).

Overview of the Following Chapters

The following chapter addresses relevant literature in the discussion of the spatial and non-spatial metaphors in interface design. This literature includes a general discussion about the properties of metaphor, the mediation effects of metaphor on learning, and the use of spatial and non-spatial interface metaphors. The methods chapter (Chapter 3) discusses the structure of the study and the basis for this structure and methods. Results of the study that are related to the hypotheses are included in the results chapter (Chapter 4). Chapter 4 also includes significant results generated from the post hoc analysis of user characteristics. A discussion and possible explanation of the results of this study are discussed in relation to the hypotheses in Chapter 5. The final chapter (Chapter 6) addresses the recommendations and contributions of this study to the field of interface design and research. This final chapter also indicates some key areas for further study in the field.

CHAPTER II

LITERATURE REVIEW

This chapter focuses on pertinent literature that is helpful in the exploration of the role of spatial metaphors in interface design. Outlined in this chapter are several important properties of metaphor that are relevant to the construction of metaphoric interfaces and also how metaphor is thought to improve learning. The role of metaphor in interface design and methods to generate and test interface metaphors are also outlined. Ineffective user interface examples are included and analyzed to determine why they are ineffective. The advantages of using space and spatial metaphors are discussed. Finally, a description of the studies investigating the effect of spatial metaphors on navigation and perception is provided.

Metaphor

Metaphor is an elemental mechanism of the mind that allows people to apply what they know from their previous social and physical experiences to other subjects and information. Metaphor, therefore, is a comparison that attempts to promote understanding (Lakoff & Johnson, 1980). A metaphor has an outer structure and an internal correspondence to its referent. The outer structure of a metaphor refers to the metaphor's general likeness to its referent. The internal correspondence of a metaphor refers to similar details between the metaphor and its referent. Metaphors are not a perfect match to their referent, and therefore only highlight the similarities between two objects or occurrences, while often concealing the differences. Metaphors with more similar details that match their referent have greater internal correspondence. Metaphors with greater internal correspondence are more likely to be understood than those with less internal correspondence (Pugh, Hicks, & Davis, 1997).

Lakoff and Johnson (1980) argue that the majority of human communication relies on metaphor. Without shared metaphoric meanings, people would fail to understand basic concepts or references in everyday conversation (Pugh, et al., 1997). Metaphor does not transmit an isolated single meaning, but rather conveys information in a holistic and coherent way. A single metaphor can imply a large set of interconnected meanings, as metaphors convey an entire situation (Ortony, 1975).

Metaphors are culturally bound, suggesting that their meaning and therefore effectiveness is culturally specific. A metaphor that has meaning in specific culture may have a different meaning or no meaning at all in a different culture (Marcus, 1998). Selection of a particular metaphor in interface design has cultural and societal implications. Because each user brings different experiences and a different background to an interface, it is important to select metaphors that will benefit all potential users (Selber, 1995).

Besides being culturally bound, metaphors are also temporally bound. For instance, the iconic representation of a telephone as having a circular dial has evolved over the past two decades to include everything from push-button phones to cellular phones (Marcus, 1998). Some researchers and theorists suggest that metaphors eventually die, losing all referent ability. These metaphors become everyday idioms in our language; "clawing one's way to the top" no longer is seen as a metaphor, but as a convention of speech. Other theorists claim that metaphors never truly die but rather retain their structural properties as well as the potential to develop new meanings (Stubblefield, 1998).

Three major theories propose how metaphors convey meaning. The first theory suggests that meaning is conveyed by substitution, where a metaphor serves as a figural substitution for a literal expression. The second theory suggests that metaphor interacts with its referent to produce new meanings. The third theory suggests that metaphor serves as an implicit comparison between two objects or experiences. These theories are not mutually exclusive and most often a combination is used to explain how metaphor conveys meaning (Ortony, 1985).

Metaphors and Learning

Metaphors are thought to facilitate learning by allowing users to connect the existing cognitive structure of a metaphor to new information (Petrie, 1979). Previous experiences become ingrained in a learner's behavior, and these previous experiences and information serve as filters for new experiences and frame new learning (Pugh, et al., 1997). Metaphors help to organize this previous experience into filters. When learners first encounter new information, they try to learn it by associating and comparing it with their metaphor-based filters. The organization provided by metaphors can help users to develop deeper reflections upon their experiences, and can serve as a starting point for further exploration of new information (Pugh, et al.).

Metaphor not only serves as a filter for new knowledge, but also as a mediator between abstract concepts and more concrete knowledge domains. Theory suggests that metaphors act as mediators between abstract thought and image schemas (Lakoff, 1990). Image schemas are the mental patterns that provide a structure for continued understanding of new material (Johnson, 1987). Schemas become filters for new information and experiences that are created from our previous experiences (Pugh, et al., 1997). Image schemas are grounded in concrete and physical experience (Johnson, 1987). They become automated through extensive practice, allowing learners to bypass their working memory, and thereby aiding in retention (Paas, Renkl, & Sweller, 2004).

Using metaphor as a mediator between mapping an image schema onto an abstract concept is not an arbitrary process, but rather is regulated. Image schemas contain internal logic. Abstract situations that highly correlate to this logic are more likely to be mapped (Lakoff, 1990). As a result of this selective mapping, it is very possible that image schemas, mediated through metaphor, constrain our abstract reasoning (Johnson, 1987).

Metaphors can be categorized according to the types of information they map. Three large categories of metaphors have been identified, including ontological metaphors, structural metaphors, and orientational metaphors. Ontological metaphors allow a person to consider abstract concepts as physical entities. Structural metaphors allow a person to map a structural source domain onto a more abstract target domain. Orientational metaphors allow a person to map the configurations and dimensions of physical space onto more abstract experience (Lakoff & Johnson, 1980). In addition to the many metaphoric categories that influence information mapping, there are different types of memory that describe how well information was been mapped. These levels of memory include recall, cued recall, and recognition.

Learning: Recall vs. Recognition

There are three basic levels of memory: recall, cued recall, and recognition. These three levels of memory are theorized to differ in the amount of processing a memory experiences. An item that is remembered must be encoded, stored, and retrieved by the learner. Recognition is the least intensive level of memory. It is theorized that recognition, or remembering having viewed an item previously, indicates that piece of information was encoded (Tulving, 1972; Tulving & Thompson, 1973). Cued recall suggests that the item was encoded, but that a person's memory must be cued to remember that item (Tulving & Osler, 1968). Recall is the most intensive level of memory, and entails the retrieval of encoded information without cues (Lang, 2000).

Metaphors in Interface Design

The term user interface has been defined by Marcus (2002, p. 24) as:

> A computer-mediated means to facilitate communication between human beings or between a human being and an artifact. The user interface embodies both physical and communicative aspects of input and output, or interactive activity. The user interface includes both physical objects and computer systems (hardware and software, which includes applications, operating systems, and networks).

Designers used metaphors early in the design of computer interfaces to decrease the various cognitive issues facing users (Hamilton, 2000). Interface metaphors can be defined as "a concept familiar to the intended set of users of a particular application [that] is borrowed to represent, or reframe, a computer operation at the software interface" (Yousef, 2001, p. 120). Marcus (2002, p. 23) also provides a definition of interface metaphors as a "substitute for collections or individual elements [that] help users understand, remember, and enjoy the entities and relationships of computer-based communication systems."

Interface metaphors are still used today to reduce the confusion faced by users when they first use an interface. For example, many online libraries use book metaphors to display online book images (Landoni & Gibb, 2000). Users often have incomplete or imprecise knowledge about the applications and software with which they interact. Metaphors allow users to access previously known domains of knowledge and the metaphor's meaning, which can help them to more easily navigate an interface (Barbosa & de Saousza, 2001). An example of an interface metaphor that refers to a user's previous knowledge domain is the computer "file" which refers to physical paper files (Condon, Perry, & O'Keefe, 2004). Correctly selected metaphors can simplify user tasks because they build upon the user's existing knowledge (Yousef, 2001).

Well-designed interface metaphors should allow users to transfer their previous knowledge about situations or physical entities to the software they are using in order to more fully understand the software's functionality and structure (Carroll & Thomas, 1982). Metaphors have been found to decrease the amount of time it takes to learn a piece of software, to promote a general mental model of how the software system functions, as well as to help novice computer users more effectively formulate possible sources of problems (Carroll, Mack, & Kellogg, 1988).

Metaphors used in multimedia interface design are often referred to as hyper-world metaphors. Hyper-world metaphors in multimedia environments use computer artifacts to create virtual worlds through the use of sound, graphics, and video. Users function much like actors in this environment, using their visual orientation and imaginative ability to navigate through an interface. As actors, they function in a fictional environment, much like actors in the fictional world of a play. Part of a user's role as an actor is to suspend his or her knowledge about the fiction of the hyper-world, just as an audience member would be involved in the plot of a play (Laurel, 1993).

Svanaes and Verplank (2000) identify several broad categories of metaphors for interface design. These include metaphors that deal with paranormal phenomena (such as magic), relational metaphors (such as human relationships), time, Cartesian space and state space. These categories of metaphors have often been examined for their potential use in interface design.

Roles of Metaphor in Interface Design

Metaphors have been identified as possessing three potential roles in the design of computer interfaces. The first is the explicit representation of the metaphor that is inherent in the design of the interface. This is the metaphor with which a user interacts. The second is the role that a metaphor plays in the generation of design ideas, including the design of the interface and the functionality of the system. Designers often use metaphors to describe the functionality of a system and its design to other designers who are less familiar with the system. They can also use metaphor to reason about the design decisions they make. This metaphoric reasoning is especially important to the third aspect of metaphor in the design process: the justification of design options. The most powerful and productive type of metaphor is one that can be used throughout the design process and fulfills all of the roles in the generation of an application. Some metaphors, although appropriate to designers, may not be appropriate to display in the user interface. These limited metaphors may still be helpful to designers by inspiring new ideas about the design of the application, even thought they are inappropriate to display to users (MacLean, Bellotti, Young, & Moran, 1991). For example, designers may use a relationship metaphor of various departments in their company to describe the functionality of a system. This metaphor would be inappropriate to display to users as they would have no knowledge of the departmental structure of the designers company. However, such a metaphor may prove helpful to designers in generating new design ideas.

Metaphors in Learning Applications

Interface metaphors used in learning applications should serve as an introduction to the content domain. Users of learning material will often only use the educational software on a limited basis, unlike other computer-based activities, such as word-processing, which are used more often. It is unlikely that a user has previous experience working with the particular learning application's interface, unlike a word processing application. Interface metaphors must also be carefully constructed to account for the skill level as well as the developmental level of the user. The user's developmental level is especially important when designing interfaces for children as well as older adults, who may only have limited knowledge of how an application works (Frye & Soloway, 1987).

Metaphors and Novice Users

Metaphors are particularly useful for users who have an incomplete understanding of the system they are using, or are less experienced computer users (Pouts-Lajus, Bessieres, Platteau, Rickenmann, Schmidt, & Boy, 1996). Interface metaphors are thought to help novice computer users who are likely to have poor mental models of the application they are using. Mental models can be defined as "[s]tructures or organizations of data, functions, tasks, roles, and people in groups or play… Mental models exhibit hierarchies of content, tools, specific functions, media, roles, goals, tasks, and so on" (Marcus, 2002, p. 23). Metaphors enable users with incomplete mental models to use a system because they allow users to access the metaphor's cognitive domain (Marcus, 2002). The majority of novice learners are more interested in learning the material presented in the interface than in spending their time learning how to use the interface's functionality (Pouts-Lajus, et al., 1996). By eliminating users' need to create accurate mental models of a system's functionality, interface metaphors allow them to spend their time learning the material presented.

Carefully chosen interface metaphors are powerful because they are taken literally by users. By understanding this metaphor, a user is more likely to be confident when using the system and is more likely to explore a system's functionality (Hudson, 2000).

Navigating hypertext can be extremely difficult for users, particularly novice users, because of the large number of nodes available. Nodes are the various pages within a website, as well as other websites to which a person can potentially navigate. Since there is no predetermined structure for the organization of these nodes, users can easily become confused when using a system. The vast size of the internet, or of a single hypertext system, can also lead to confusion. These problems can be generalized into two main categories of hypertext problems: cognitive overload and disorientation (Boechler, 2001).

Cognitive Load

Metaphors are also thought to decrease the amount of cognitive load that a person faces while participating in a task. Cognitive load refers to the number and amount of necessary mental resources that are used to complete a task (Kim & Hirtle, 1995). Cognitive load can be measured in four basic ways, including user behavior, self reports about the difficulty of using a page, physiological indicators (such as a user's pulse rate) as well as task performance (Schultheis & Jameson, 2004). Internet users must perform several tasks at once, which can include browsing general topics, surfing, finding items of interest, and comparing items of interest. Users can experience cognitive overload when they are forced to undertake all of these tasks simultaneously (Kim & Hirtle, 1995). Interfaces that lack enough context can also lead users to experience cognitive overload. Context serves as a valuable tool for users' navigation and learning (Park & Kim, 2000).

Cognitive overload often occurs because of the lack of conventional cues provided by traditional physical documents, such as page numbers and chapters in books, which provide cues to users as to their location (Gygi, 1990). To complicate the matter of navigating, hypertext is multi-linear (Conklin, 1987).

It is important to recognize several degrees of cognitive load (Paas, Renkl, & Sweller, 2004). When the cognitive load is too low, it is likely that a user will not be engaged in a task. If the amount of cognitive load is too high, as in the case of cognitive overload, then users will be so overwhelmed that they will not be able to accomplish a task (Teigen, 1994). A correct amount of cognitive load allows users to be engaged in the learning task, while not having to attend to a system's functionality (Paas, et al., 2004).

In order to reduce cognitive load, researchers have also suggested several considerations when designing an interface. These include the level of attention necessary for the user to attend to the task, including how difficult it will be for a user to return to a task if they are interrupted. Designers should also consider the conceptual complexity of the material as well as learner's previous experience and knowledge. Finally, designers should consider the memory load of a task, including how much new material must be learned, and how much material must be held in the user's short-term memory (Cohen, Giangola, & Balogh, 2004).

Disorientation

Disorientation is a second major concern for designers of hypertext environments. The pure number of choices and the number of ways that a person can navigate to a single source of information can lead to disorientation (Conklin, 1987). Novice internet users are much more likely to feel disorientated than others who have more accurate mental models of the systems they are using (Mayhew, 1992).

Disorientation can be defined through three distinct user behaviors. These behaviors include the user not knowing where to navigate to next, not knowing how to reach the link they desire, or not knowing where they are in relation to the rest of the hypertext document (Edwards & Hardman, 1989).

Designing Effective Interface Metaphors

Erickson (1990) outlines several steps to create useful and understandable metaphor-based interfaces. These three steps include determining the functionality of the system, identifying user problems, and generating a correct metaphor.

Since metaphors serve as a model for how the system functions, the first step in creating an appropriate interface metaphor is to fully understand how a system operates (Erickson, 1990). Since all metaphors are only partial matches to their referents, it is important to note how the metaphor matches the functionality of the system and how it does not. In noting a system's functionality, Erickson (1990) states that is important to realize not only how the system works, but also how long it takes to finish an action. In order to overcome the problems of poorly chosen metaphors, Hudson (2000) recommends that metaphors should only be chosen for tasks that are in existing problem domains. For example, interface metaphors are more likely to be useful in online shopping situations. Shopping markets and stores exist in the physical environment, and therefore lend themselves easily as metaphors for these same activities in a computer environment. Creating interface metaphors for new problem domains can be problematic, as often these new domains do not lend themselves to metaphoric comparisons to the physical world (Hudson, 2000).

The second step in creating a useful interface metaphor is to understand users' problems, including identifying what aspects of the system are similar to other systems a user has used, and what aspects are different. Erickson (1990) recommends several methods for understanding user difficulties. These include observing users while they are using the system and encouraging them to verbalize their problems. A second method is to have a user observe a designer using a system. In this scenario, the user is encouraged to verbalize problems when they do not understand an action or functionality.

The third step in designing a useful metaphor is metaphor generation (Erickson, 1990). Metaphor generation involves soliciting and considering designers' and users' input. Often, metaphors are implicit in the designers' and users' descriptions of the system's functionality. Since metaphor is prevalent in our society as a linguistic and cognitive resource, designers have probably used metaphors to describe the functionality of the system during the design process. However, since many designers are not fully aware of the problems and difficulties that users may face when using the system, often the metaphors offered by designers are incomplete and are poor matches. To prevent using a poorly matched interface metaphor, Erickson (1990) recommends using metaphors that have been generated through the user observation stage of metaphor generation.

Hudson (2000) recommends a series of considerations when generating metaphors for graphical interfaces. Interface metaphors should provide adequate clues to users so that they can effectively navigate an interface. Providing adequate cues enables the users to access the metaphor's established cognitive domain, which will be helpful in using the system. Interface metaphors should not rely only on appearance, but should act like their referent. For instance, if a shopping cart is used as a metaphor, the shopping cart should not only visually match the appearance of a shopping cart, but should also behave like a shopping cart. Designers should choose metaphors that have concrete and widely accepted visual appearances. Finally, designers should avoid culturally specific metaphors that may not help all of their potential computer users (Hudson, 2000).

Not only is the appearance and function of the interface the only important considerations when choosing an interface. The designer should choose metaphors that correctly match the users' mental models (Cooper, 1995). Not all users share common mental models of the same applications. Some users will have poorly constructed mental models, which must be considered when designing an interface (Mayhew, 1992).

Previous studies have shown that there are significant differences in user's mental models based upon their culture. Choong and Salvendy (1999) found that Chinese individuals and U.S. individuals appear to have different mental models of the same objects. When both groups were asked to describe the contents of a typical house, they found that Chinese participants were more likely to emphasize the relationships between individuals in a home, whereas U.S. individuals were more likely to emphasize the physical contents, their categorization, and function. When U.S. participants were faced with an interface based upon the Chinese mental model of a home, they performed considerably less well than when they used a mental model derived from the U.S. perspective of a home. Chinese participants also performed significantly poorer when faced with a U.S. based mental model interface than with a Chinese-based mental model interface (Choong & Salvendy, 1999). This finding emphasizes the importance of cultural consideration when generating appropriate metaphors for interface design.

Consideration of user mental models is very important to the amount of cognitive load that a user will experience. Mental models effect how a user thinks about a task. Mental models also affects whether a user finds a correlation between the interface and their previous experience and knowledge, and if they are able to use this correlation to help them navigate a website. Mental models also effect how users will understand a task once they have completed interaction with the metaphoric interface (Calongne, 2001).

Once a metaphor has been generated, it must be evaluated for its effectiveness. Metaphors can be evaluated using four criteria: the amount, applicability, and representability of the metaphor's structure as well as the extensibility of the metaphor. Metaphors with a high degree of structure allow the functionality of the system to be clearly articulated by a user. Metaphors with a high degree of applicability strongly match their referent. Ideally, interface metaphors are easily represented through visual or auditory channels. Ideal metaphors have high extensibility, suggesting that their structure easily be used for later developments in a system, including increased functionality

(Erickson, 1990). Carroll et al. (1988) suggest a procedure similar to Erickson's (1990) system of selecting effective design metaphors. However, Carroll et al. suggest an additional step that includes identifying mismatches between the metaphor and its referent and creating design strategies to help users to manage these mismatches.

Ineffective Metaphors In Interface Design

One of the challenges faced by both users and designers is the use of appropriate metaphors. Several inappropriate metaphors, including the "trash can" and "desktop," have often been cited as ineffective metaphors.

An instance of an inappropriate use of an interface metaphor is the "trash can" metaphor in Macintosh computers. The "trash can" icon serves two main purposes: deleting files and ejecting disks and CDs. By dragging files to the "trash can," users can delete files. In order to eject disks and CDs, users must also drag the disk or CD icon to the "trash can." Users, especially beginners, display discomfort and confusion with the process of ejecting a disk on the Macintosh. Many view this process as "throwing" their files away (Hamilton, 2000). Another common problem with the "trash can" metaphor is that the function of deleting files is not correctly matched with the attributes of a physical trash can. The Macintosh "trash can" never becomes full, unlike a physical trash can. This lack of matching of the "trash can" metaphor to its referent can lead to user confusion. Users who do not empty their physical trash cans until full may neglect to empty their virtual "trash cans." The virtual "trash can" does not indicate when it is full, so users may unknowingly fill up the majority of their disk space with deleted files (Stubblefield, 1998).

Many researchers have also stated that they believe that the common "desktop" metaphor used in the main interfaces of both Macintosh and Microsoft operating systems to be an ineffective metaphor. Several researchers feel that it is a metaphor that is poorly matched to its referent of a physical desktop. Physical desktops most often do not have the same features as computer "desktops." It is unlikely, for instance, that any physical desktop will have a trash can on it, or be covered in wallpaper (Genter & Nielson, 1996).

When analyzing any interface metaphor, it is important to recognize the development of the metaphor in a historical and design perspective. Firstly, the main function of the desktop was to enable novice users to navigate a computers functions and applications without having to know advanced code. The desktop was also designed for a limited number of applications for office-orientated activities and as familiarizing metaphor. The computer itself was highly limited in computational resources when compared to current processing and storage needs. These resource constraints were reflected in the quality and capabilities of the initial black and white screen. Computers themselves were probably connected at most to one printer. Advances in computer design and technology, as well as the introduction of the internet, have changed the main functions and uses of the common computer since the first introduction of "the computer for the rest of us" in 1984 (Genter & Nielson, 1996, p. 71). Genter and Nielson (1996) argue that the "desktop" metaphor no longer matches user needs or current computer technology. The problem with the "desktop" metaphor is not that it has always been ineffective, but that the introduction of new technology has made the metaphor less relevant and inappropriate for current users. It is possible that the early success of the "desktop" metaphor has prohibited designers from developing more appropriate interface metaphors by constraining their creativity and their ability to create new ideas beyond the "desktop" metaphor (Genter & Nielson, 1996).

Another common interface metaphor that is inappropriate is the "file" metaphor in Microsoft Office programs. The "file" metaphor of a single computer document does not directly match its referent of an office file. Office files often contain multiple documents about a single subject, such as a doctor's medical file of an individual that may hold several documents about a person's medical history, laboratory tests, and previous visits. A "file" on the computer, however, refers to a single document. A study of administrators and researchers at a university demonstrated that those who worked with office files were much less likely to use the file metaphor to refer to computer documents (Condon, et al., 2004).

Interface metaphors have many critics, especially those who feel that metaphors constrain users or designers (Hudson, 2000). These criticisms often stem from researchers' and theorists' examinations of the "desktop" interface and user behavior. Other researchers have suggested that metaphors constrain design of user interfaces. Hudson (2000) argues that although metaphors may be taken literally by inexperienced users, advanced designers are more likely to understand the matches between the metaphor and the functionality of a system, and therefore the mismatches.

Spatial Metaphors in Interface Design

Spatial metaphors, or metaphors that compare the position of objects in space, are often used in interface design. The term virtual navigation is a spatial metaphor, which presents the internet as a spatial area that can be navigated, much like a physical space (St. Amant & Dulberg, 1998). Previous research on spatial metaphors has suggested that they decrease retrieval time and increase the user's knowledge of the structure of a website or information database when compared to non-spatial interfaces (Padovani & Lansdale, 2003). Other studies have shown the use of metaphors may increase user satisfaction and reduce user confusion, but may not actually increase the accuracy of the task (Suttcliffe, Ennis, & Hu, 2000).

Advantages of Using Space as a Metaphor

Space embodies several important properties that are useful to interface design. Spatial structures can convey a large amount of information in simple intuitive ways such as relationships between objects and visualization of past actions. All human beings interact with space in their daily lives and with spatial structures (such as buildings or towns). These properties are what make spatial metaphors so useful in interface design (Carroll, et al., 1988; Erickson, 1993; Kuhn & Frank, 1991). Spatial interface metaphors rely on the spatial knowledge that is fundamental to users' interactions with the physical world (Jones & Dumais, 1986).

Spatial memory is very important for humans interacting in their worlds. If spatial memory is important in creating a mental map of a human's physical environment, then it is likely that designers will be able to use spatial design to facilitate users' creation of mental maps of virtual interfaces through spatial metaphors (Robertson, Czerwinski, Larson, Robbins, Thiel, & van Dantzich, 1998). St. Amant and Dulberg (1998) argue that the term virtual navigation is a metaphor for finding direction and place in physical space. If virtual navigation is finding direction in a virtual space, then it is likely that providing spatial cues in the interface will aid in user navigation.

Traditional non-spatial interfaces do not take advantage of user spatial ability or memory. Previous work has suggested that this traditional structure is disadvantageous for certain users. Vicente, Hayes, and Williges (1987) demonstrated that users with low spatial ability perform poorly when using hierarchical file structures. Users with low spatial ability also tend to perform poorly when faced with non-spatial web pages (Chen & Rada, 1996; Mcgrath, 1992).

Use of Spatial Metaphors

Spatial metaphors have been used in several applications. Room metaphors have been used in collaborative workspaces (Greenberg & Roseman, 1998; Shiozawa, Okada, & Matsushita, 1999). Book metaphors have been used extensively in online libraries (Landoni & Gibb, 2000). Several educational applications for young children use spatial interface metaphors such as classrooms (Gueraud, Peyrin, Cagnat, David, & Pernin, 1994; Oosterholt, Kusano, & Vries, 1996). Yousef (2001) proposed that these metaphors are useful for designing interfaces for users with special needs and the elderly, who often have decreased mobility, cognitive ability, or visual acuity. Spatial metaphors have also been used in the construction of certain medical applications to reduce the amount of training needed to familiarize health professionals with an interface. These metaphors have been shown to help health practitioners develop more accurate mental models of the human body (Hinckley, Pausch, Proffitt, & Kassell, 1998).

Spatial Metaphors and Visual Skills

A common problem with purely spatial interfaces is that they do not engage our visual skills. This is a common criticism of the desktop metaphor. Although the spatial metaphor takes advantage of space and spatial memory, users often find it difficult to establish a sense of place because their visual skills are not being fully utilized (Darken & Sibert, 1996; Nielsen & Lynebaek, 1989). Lewis, Rosenholtz, Fong, and Neumann (2004) argue that in order to fully engage the brain for visual recognition of spatial metaphors, the interface must have both a spatial format as well as have a distinctive scenery appearance. Scenery is defined as visual recognition items that are common to users. These can include icons that represent specific applications on the desktop as well as the background of the interface. This scenery can be 2D or 3D in appearance. Using appropriate scenery allows users to fully use their spatial and visual knowledge to help them find items and navigate effectively through an interface (Lewis, et al., 2004).

The importance of visual recognition has been researched by Standing, Conezio, and Haber (1970) who found that subjects were able to accurately recognize 90% of images previously shown to them, even if they were shown hundreds of images. Several studies have also demonstrated that people prefer to both visually and spatially organize their workspaces and documents (Lansdale, 1988; Malone, 1983; Mander, Salomon, & Wong, 1992). Including scenery in an interface allows users to use both visual and spatial skills to search, navigate, and remember the placement of items in an interface (Lewis, et al., 2004).

Previous Research on Spatial Metaphors

Previous studies have focused on testing various spatial metaphors and their effects on navigation and perception.

Spatial Metaphors and Navigation

Padovani and Lansdale (2003) studied the effect of a spatial metaphor of a home on finding various objects around the "home" versus a non-spatial metaphor of relationships to find witnesses to a crime. Padovani and Lansdale (2003) found that the spatial metaphor of the home decreased time taken to complete the task and increased task accuracy. Subjects in the spatial-metaphor interface condition were able to more accurately draw a map of the appropriate site structure, compared to those in the non-spatial condition.

Kim (1999) found that in the study of online shopping malls, organizing the content around the spatial metaphor of an actual mall helped subjects buy ad hoc items (gifts for a specific interest, such as a brother who was interested in technology) compared to non-spatially organized online malls. When subjects were searching for items that were clearly specified, such as a computer, performance was equal between the two metaphors.

A case study of a spatial metaphor interface, based on a city, designed as a travel agent's resource for booking customers' travel was investigated by Marcus (1998). Although the majority of travel agents felt that this interface was more effective in helping them to book customers' travel, it was not compared to a non-spatial interface.

The use of spatial metaphors has also proved helpful in teaching grade school children to construct web pages. Bromme and Stahl (1999) demonstrated that children who were taught web design using spatial metaphors to describe the structure of the internet and the functionality of web pages constructed more functional web pages and were better able to map the structure of their web pages than students who were trained to create web pages without a spatial description.

Spatial Metaphors and Perception

Sutcliffe, Ennis and Hu (2000) studied the effects that a spiral display of search results had on the retrieval of correct articles. In this study, subjects were encouraged to verbalize their problems (through a talk aloud protocol) with the system, while using it to correctly identify articles retrieved from a search that contained information on a certain topic. The spiral display showed relationships between the data, with results that were closely related spaced more closely on the spiral. At the end of the experiment, subjects were interviewed to determine how useful they found the interface. Despite users finding the spiral metaphor easy to understand and helpful, they performed very poorly on the article retrieval task. Researchers suggested that this performance may have been due to users' unfamiliarity with the subject matter.

Problems with Previous Research

Some of the previous studies involve irrelevant tasks for their subjects, who were most often students. Some of these tasks included searching for outdoor items around a home, discovering relationships among students to solve a crime, or working with search results in an unfamiliar field of study unrelated to the student's major or classes (Suttcliffe, et al., 2000; Padovani & Lansdale, 2003). Irrelevant tasks, such as searching for articles unrelated to user interest, decrease learner motivation and can cause poor performance (Driscoll, 1994). It is also possible that many of the metaphors used in these studies may not be culturally relevant to the subjects. This study, through using a task relevant to the subjects (searching for an on-campus job) and through using an appropriate spatial interface that is closely related to the task and likely to be familiar to subjects (the Ithaca College campus), aims to improve on previous studies.

Summary

Metaphors were used early in computer interface design to reduce user confusion (Hamilton, 2000). It is theorized that metaphors are only helpful to novice users and that metaphors should not be used for more advanced users, although this has not been investigated empirically (Marx, 1994). Metaphors are thought to facilitate learning by acting as a mediator between the users previous experiences and knowledge, and image schemas (Lakoff, 1990). Interface metaphors have been used to facilitate user navigation and user understanding of the functions of a computer application (Marcus, 2002).

There are three basic functions of metaphors in interface design: the interface metaphor with which a user interacts, metaphors which designers use to describe the functionality of the system, and metaphors that designers use to make design decisions (MacLean, et al., 1991). Interface metaphors may be particularly useful in learning applications. Metaphors are thought to decrease cognitive load, as they allow novice users to access the metaphor's cognitive domain without having to create new mental models for how an application functions (Marcus, 2002). High amounts of cognitive load can interfere with a person's ability to effectively learn material (Teigen, 1994).

Spatial metaphors are commonly used in metaphoric interfaces. Humans interact with space in their daily lives and spatial structures can convey a large amount of information such as object relationships and visualization of past actions (Carroll, et al., 1988; Erickson, 1993; Kuhn & Frank, 1991). Previous research on spatial interface metaphors has suggested that they improve navigation efficiency in web pages when compared to non-spatial metaphors (Padovani & Lansdale, 2003). Other research has shown that users have a preference for spatial interface metaphors when compared to non-spatial metaphors (Suttcliffe, et al., 2000).

CHAPTER III

METHODOLOGY

This study included several components to test the three hypotheses outlined in the introduction, including a user characteristic survey, an internet-based task, a recall and recognition test, as well as short interview to examine the user's perception of the interface they used. Participants were first asked to fill out a short survey about their computer usage, internet usage, and previous work experience. Participants were then randomized into one of two conditions, and used either a spatial or non-spatial metaphoric interface to complete an internet-based task. This task involved searching for several on-campus positions that matched a description they were given. The participants' navigation was tracked during the task and their accuracy on the task was recorded. After completing the task, the participants' recall and recognition of the positions and descriptions they read during the exercise were tested. Finally, the participants were interviewed to assess their perceptions of the interface they had used. Interviews were chosen because methodologically they provide richer information than surveys, as researchers can explore ideas and generate new questions from the information presented by the subject.

Previous Research Methodology

Many previous studies have addressed the impact of metaphors on retrieval time and memory of site structure; this study investigates the effect of metaphor on retention and recognition.

The method devised in this experiment is similar to previous studies that use two experimental conditions (Kim, 1999; Padovani & Lansdale, 2003). One condition was based upon a non-spatial metaphor of an index, and the second upon a spatial metaphor, based upon an aerial view of the Ithaca College Campus. These two conditions served as the independent variables for the experiment. The dependent variables were the subject's performance on the learning retention exercise, navigation, and perceptions of the interface.

Participants

Participants were recruited from various lower-level undergraduate psychology classes. Thirty participants chose to participate and complete the experiment. Participants ranged in age from eighteen-years-old to twenty-years-old. The majority of the students were freshman or sophomore students, though one subject was a junior. Fourteen of the participants were male; sixteen were female. Twenty-five participants indicated that they were American, one participant self-identified as Chinese, one participant self-identified as Columbian, one participant self-identified as Serbian, and two participants did not indicate their nationality.

A convenience sample of participants was used. These participants were recruited from the Ithaca College campus through psychology classes that offered extra credit for participation in experiments. The study entailed two experimental conditions; participants were randomly assigned to each condition using a random table of numbers that was computer generated.

Questionnaire

Participants were asked to fill out a short characteristic questionnaire (Appendix A). This questionnaire included demographical information (gender, age, nationality, and college year), computer usage (how many hours they used a computer per week, applications used, operating systems, and programming ability), internet usage (frequency of internet use and if they had ever created and published a web page), and work experience (including on and off-campus positions).

The choice of what to include in the questionnaire was based upon the literature review. Although many previous studies mention the age and gender of subjects, they have not analyzed whether differences in performance or perception of the interface occurred due to subjects' age or gender. Subjects' nationality was noted to determine whether differences in performance or perception could be due to the choice of metaphor. Collecting information about the subjects' computer use, internet use, computer ability, and programming experience allowed the researcher to compare these characteristics to subjects' perceptions, navigation, and retention of the information found in the interface. Information about the student's previous experience with campus or non-campus employment may have explained better recall on certain items. A student who has held an on-campus job is more likely to remember the qualifications and duties of their position. For instance, a student who has held a library position is more likely to be familiar with and remember the tasks associated with library positions than the tasks associated with dining hall positions. Although Kim (1999) does discuss participants' previous experience with the task and familiarity with the content of online shopping malls, the majority of the other studies do not analyze participants' familiarity with the content.

After completing the questionnaire, participants were asked to perform a series of job searches using an interface designed by the experimenter.

Experimental Conditions and Task

Conditions

The experiment was designed with two conditions. The first condition interface was based upon the non-spatial metaphor of an index, and included no graphics (see Appendix D.1). In this condition, all links are presented in alphabetical order, much like an index in a book.

In the second condition, the interface was based upon the spatial metaphor of the Ithaca College Campus. This interface was constructed using an aerial picture of the Ithaca College Campus, with the same buildings labeled as in the non-spatial metaphor condition (see Appendix D.2). The spatial metaphor of the campus is based upon the global world metaphor used in the design of a travel-agent resource (Marcus, 1998). The Ithaca College campus was chosen as the spatial metaphor condition because most Ithaca College students are likely to be familiar with the layout of the campus. An aerial picture was chosen to represent the spatial layout of the campus because previous researchers have stressed the use of visual scenery to facilitate the advantages of using spatial interfaces (Lewis, Rosenholtz, Fong, & Neuman, 2004).

The web pages used in this experiment were created using Dreamweaver MX 2004. A parallel structure and similar content was maintained between the two interface designs. Both the spatial and non-spatial interface included the same information, as well as the same links and labels. This design is similar to Kim's (1999) study of online shopping malls, in which the spatial and non-spatial interfaces contained the same information and links. This design attempted to remove the confounding variables found in previous research that entailed differences in task and in the content of the interface (Padovani & Lansdale, 2003).

Randomization

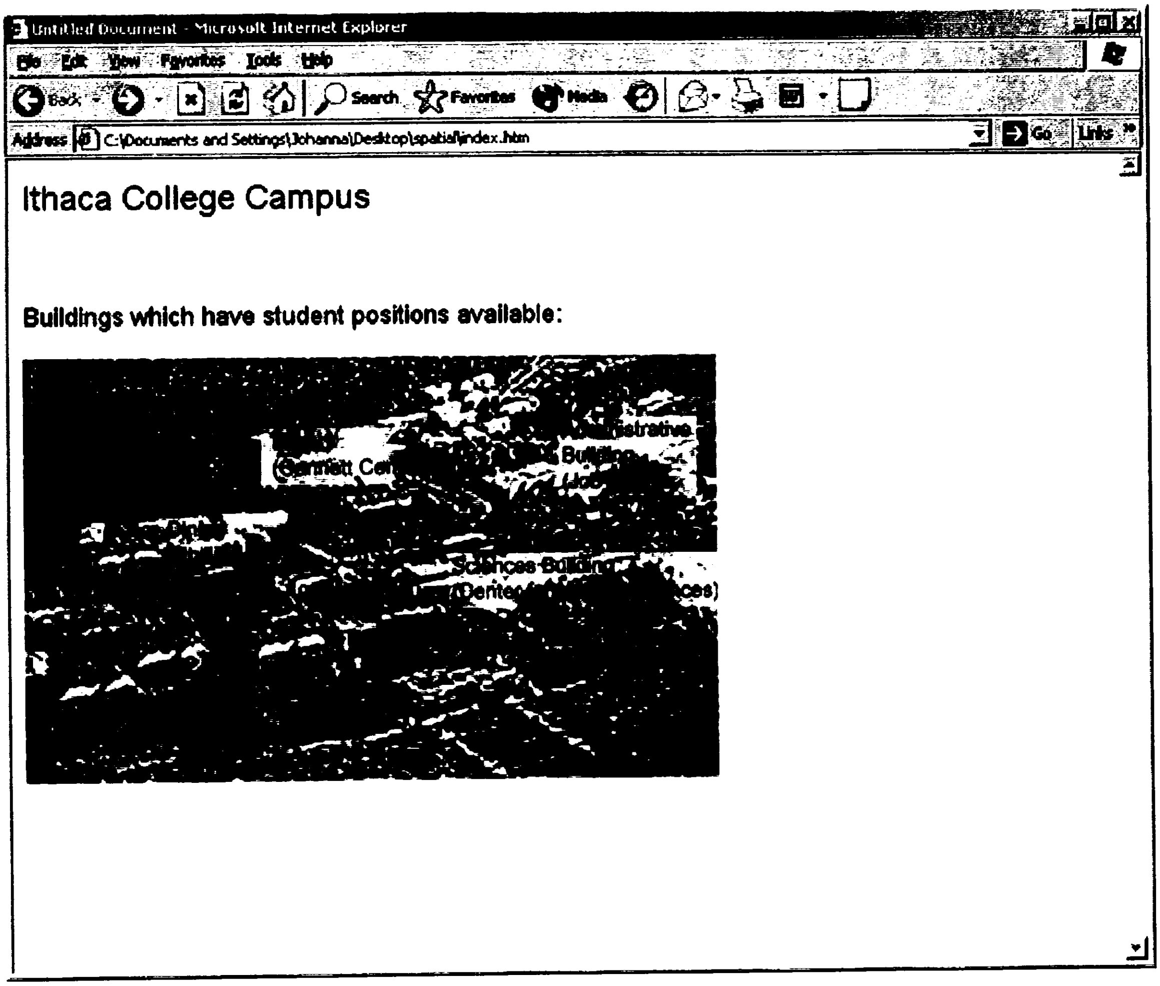
Participants were randomly placed into one of two conditions that were coded using two letters, A and B. In order to effectively track subjects, each subject was also assigned a number. In order to protect subject's confidentiality, these numbers did not correspond alphabetically to participants' names and were not recorded on the experimental sign up sheet that had been presented in their classes.

Design of Experimental Task

The task chosen for this experiment was searching for an on-campus employment position (student job). Participants were asked to search and record five campus positions that matched two job duties or characteristics. This task was chosen because of its relevance for participants. In the user characteristic survey, thirteen participants indicated that they had held campus jobs; during the interview, several participants noted that they had unsuccessfully searched for an on-campus position; and several participants also indicated that they had friends and classmates who were seeking on-campus employment.

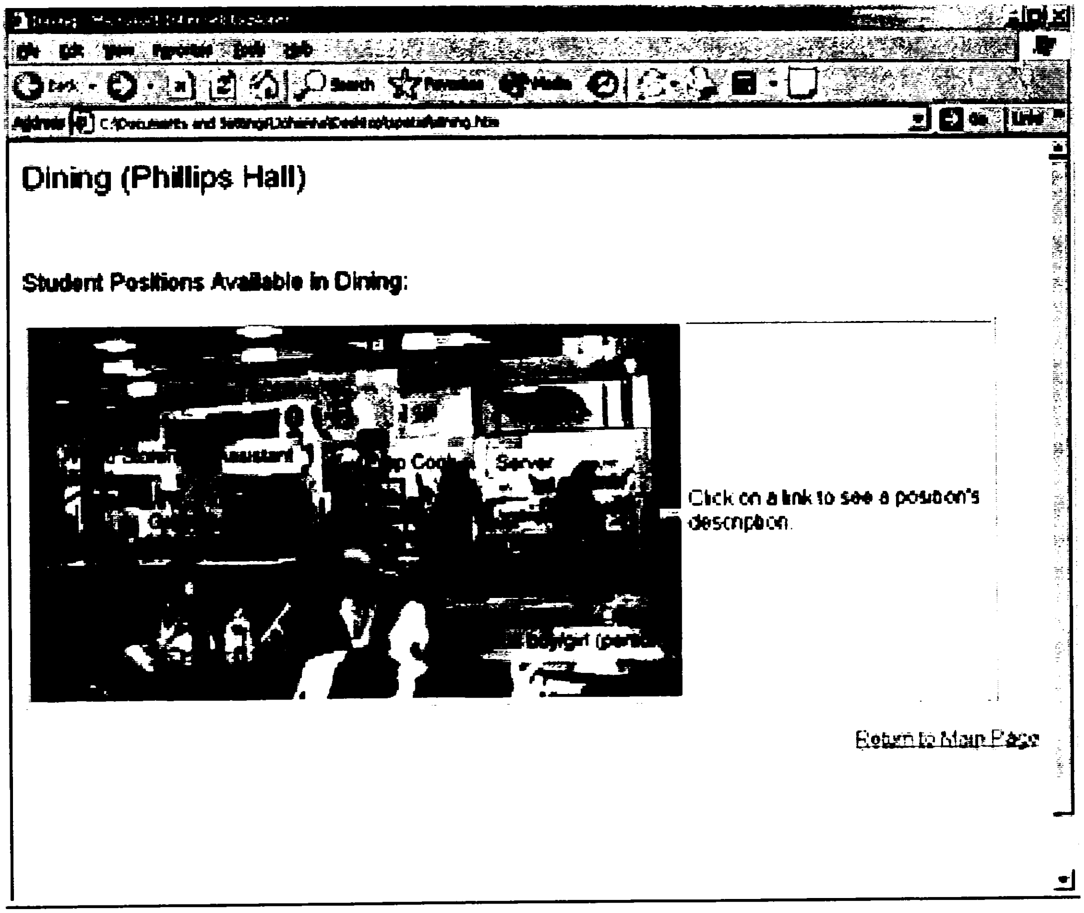
One position in the interface matched the characteristics with which they were presented for each query. For example, participants were asked to find a position that involved handling money and having good customer service skills. In order to find such a position, participants would "search" for this position by clicking on the various buildings represented in the Ithaca College interface (*Figure 1.1*). This job description was matched by the Cashier Position within the Dining building.

Figure 1.1 Spatial Interface: Campus Buildings



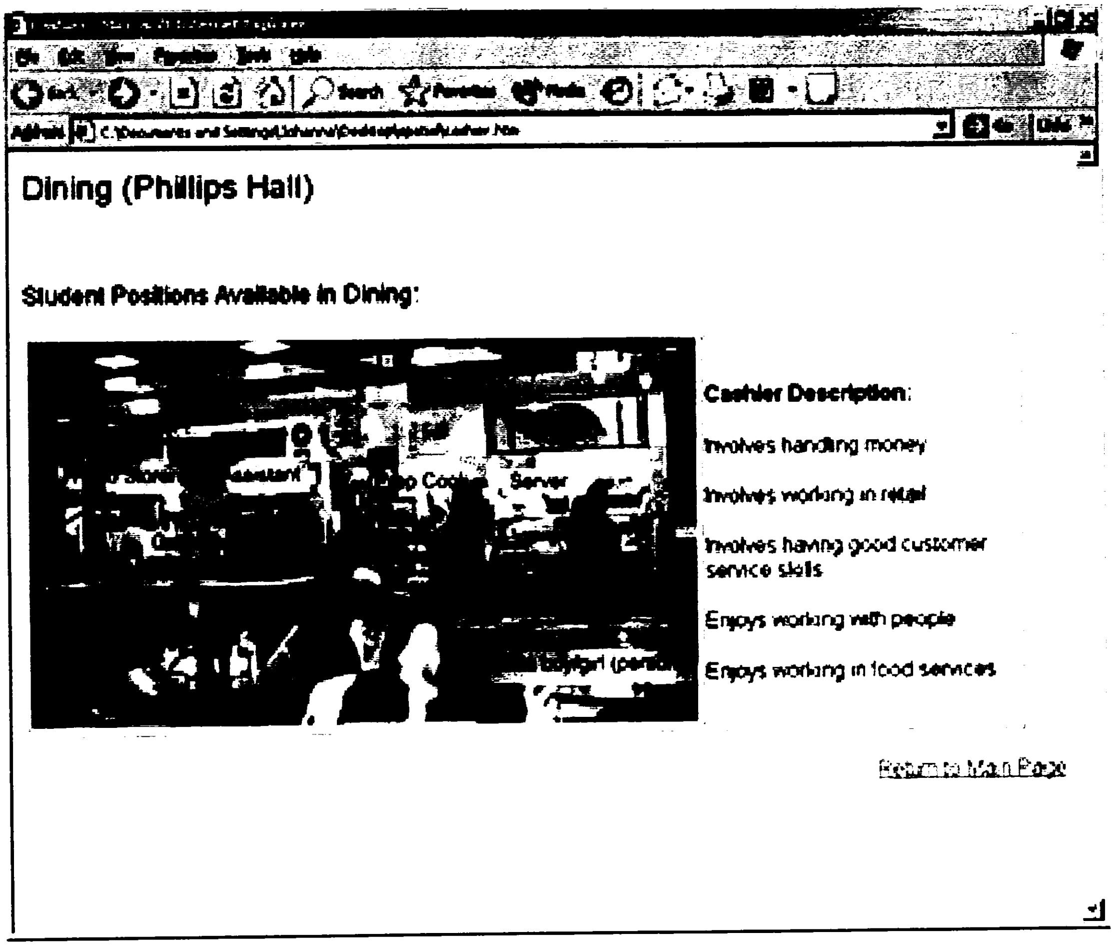
Once the users clicked on the building icon, a new page would open showing a simplified schematic of the inside of each building representing the types of positions available. For instance, in the dining example, the positions included Cashier, Food Storeroom Assistant, Server, Prep Cook and Bus Boy/Girl. Each of these positions was represented by an area in the schematic; for instance, the Cashier position was associated with the registers and labeled "Cashier" (*Figure 1.2*).

Figure 1.2 Spatial Metaphor Interface: Positions in Dining



By clicking on the actual position title, the job description appears in the right side of the screen. Once participants found an appropriate position, they recorded this position on a sheet of paper as fulfilling the job requirements (*Figure 1.3*).

Figure 1.3 Spatial Interface: Cashier Position Description



Since the two condition interfaces contained the same information and the same link structure, navigation within each condition was fundamentally the same. In the index scenario, the participant searched for the same five positions using the same hierarchy, except that these positions were represented as an alphabetically ordered list of position titles (see *Figure 2.1*, *Figure 2.2*, and *Figure 2.3*).

Figure 2.1 Index Interface: Campus Buildings

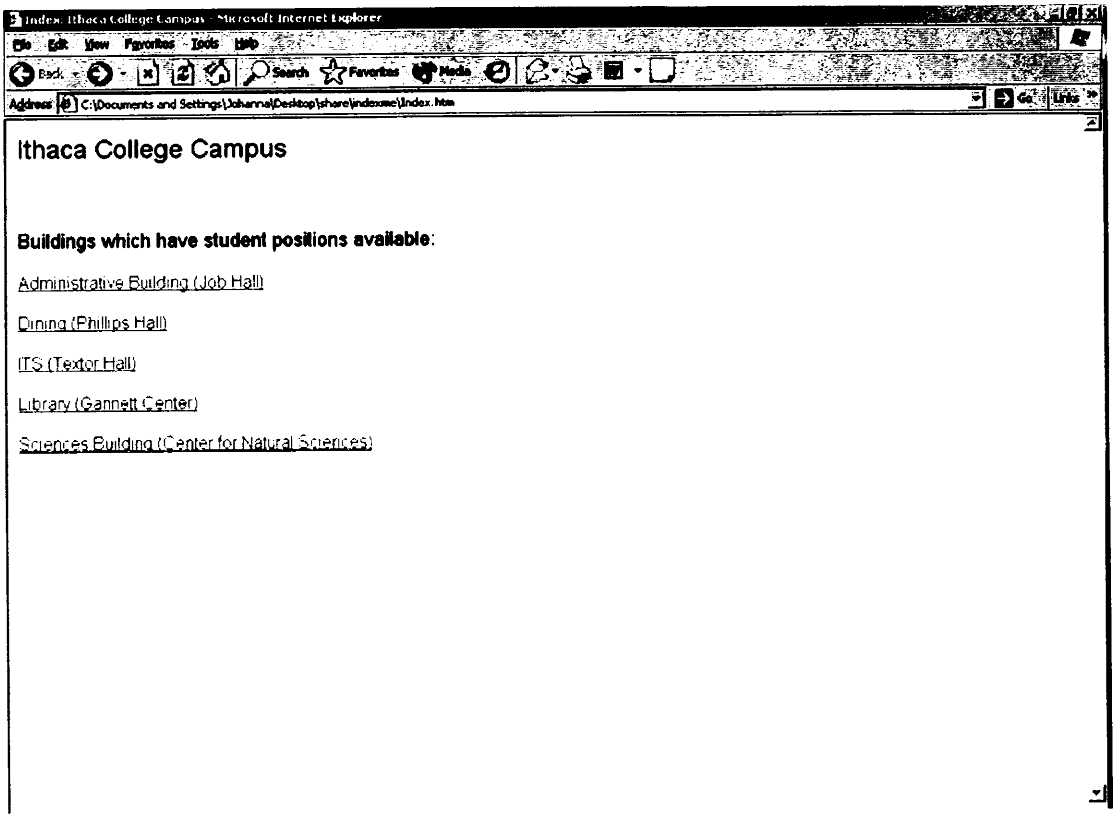


Figure 2.2 Index Interface: Positions in Dining

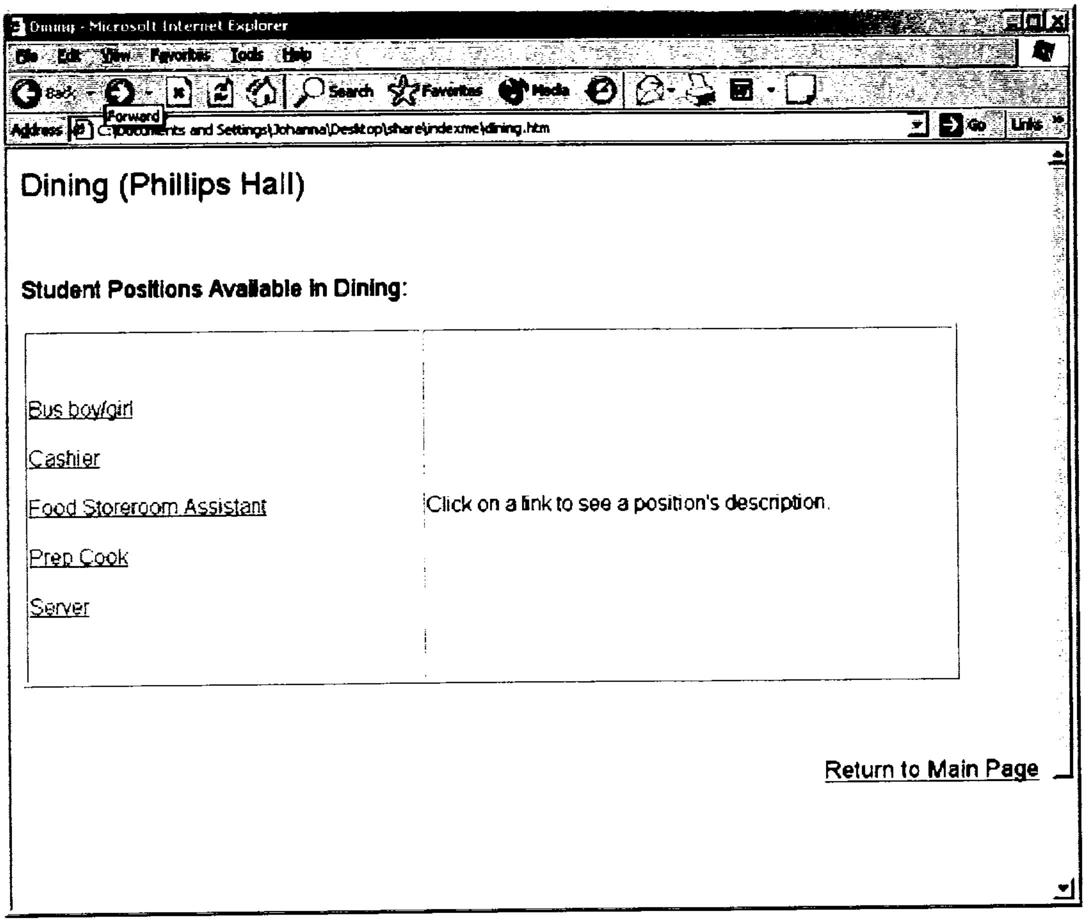
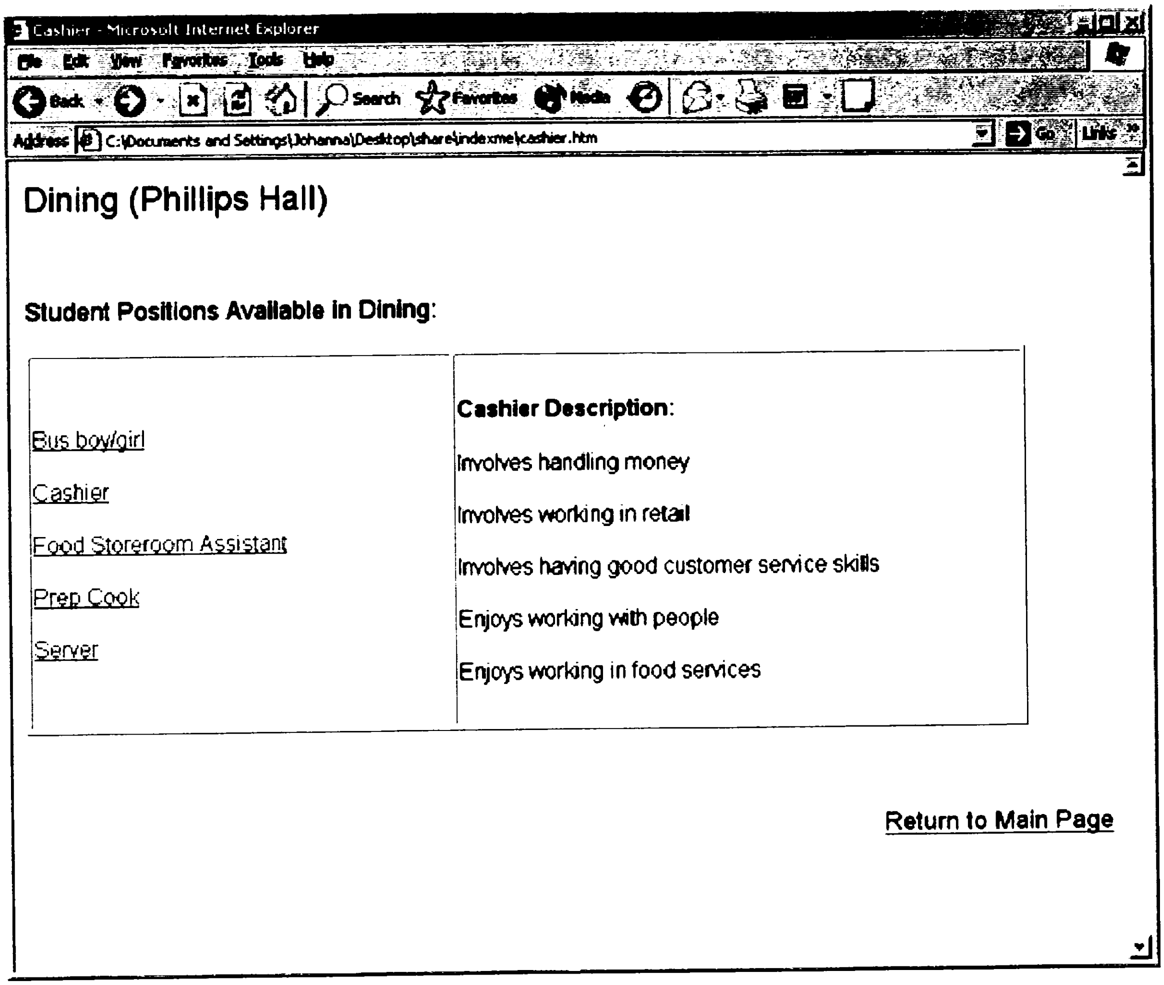


Figure 2.3 Index Interface: Cashier Position Description



Tracking

Participants' actions were tracked using a desktop web server that tracked all links clicked by a participant along with the time they were clicked to the nearest second. The product of this web server was a log file similar to those produced by typical web servers. A desktop web server was chosen to account for any differences in loading times of pages due to connection speeds or server irregularities. In order to facilitate analysis of the server logs, participants were instructed to find each position in order listed on the task exercise sheet.

The web page was run locally on the researcher's laptop. One laptop was used throughout the experiment to insure that differences in internal processing speed or other confounding factors would not affect the web pages' loading speed.

Prior to the start of the experiment, testing was done to check the approximate load times of the pages between the two conditions. It was determined that the pages in the spatial metaphor condition did not load significantly slower than the pages in the non-spatial metaphor condition.

Retention Testing

The retention test was administered after the participant had finished searching for the five positions. Two types of retention were addressed in this study, recall and recognition. The form used to collect retention data is provided in Appendix B. Retention was operationalized by testing recall through an open-ended form, in which subjects were required to record as many positions and their associated duties as they could remember. Recognition was measured using a true false testing situation that tested participants' memory of the positions and their duties.

The recall portion of the test involved two separate segments. The first segment asked participants to list the five positions they had found as a result of the search. The second segment asked subjects to recall as many duties as they could remember associated with each of these positions. Participants were instructed to record as many positions and duties as they could remember, and to write the names of the positions and the exact duties as accurately as possible. The forms were left open-ended so that subjects could write down their interpretations of the positions. This open format was chosen to test users' recall since metaphors are suggested to increase learning by allowing easier memorization (Carroll & Mack, 1985; Laurel, 1993).

The recognition part of the retention test was administered separately. It consisted of twenty true and false statements, including statements that were true about the positions they had found and statements that were false. This instrument was specifically designed for this study. Test item recognition is a second important component of memory. It is more likely that a subject will recognize information than be able to clearly recall information. Although recalling information may be important for classroom-based instruction, few people are able to recall communication information in such detail. Recognizing information is important for many communication studies, as it is most important that learner recognizes the correct information, rather than display free recall of the information. This method is fully described by Shapiro (1994).

The recognition portion of the retention test was administered separately so as to prevent participants' memory from being primed by the statements they saw, and correcting their answers on the recall portion of the retention test. Participants were instructed to answer the statements as well as they could remember.

Interview

The researcher administered a short interview following the retention test. This interview was audio-recorded, and the researcher took notes. The one-on-one interview was designed to assess participants' comprehension of the website, whether they noticed the spatial or non-spatial metaphor, whether and how helpful they found the interface, and their recommendations for improving the website. This methodology is based in part on Diehl and Ranney's (1996) assessment of the visualization of spatial tools. For the complete Interview protocol, see Appendix C.

The questions in Appendix C were developed from a study on the desktop metaphor by Ravasio, Schar, and Krueger (2004), in which users were asked about their use and perceptions of the Windows or Macintosh desktop interfaces and their procedures for storing files.

Data Analysis

Navigation, Recall, and Recognition Data

Task accuracy, tracked behavior, and retention test information were examined quantitatively. The alpha level for this experiment was set at 0.05, or 5.0%. The ANOVA statistical test was chosen because this study is an independent-measures research design with multiple variables. The ANOVA statistical test allows several means to be compared while reducing the error that would be found in using multiple t-tests. The alpha level was set to 0.05 because this is considered an acceptable alpha level for behavioral science research (Gravetter & Wallnau, 2000). All statistical analyses were carried out using SPSS.

Task Accuracy

Task accuracy is defined in this study as the number of correct positions listed on the answer sheet during the task itself. Each participant's answer sheet was scored separately. An answer was defined as correct if the position recorded by the participant on the answer sheet matched the description that they were asked to find. The server log was also checked to verify if a participant had indeed viewed that position's description in their search. A correct answer received a score of one; an incorrect answer received a score of zero. The score for each individual position for the participants in each condition were added, and a mean was calculated. Each participant's total task accuracy was also computed. The number of positions each participant correctly recorded was totaled and from these totals the mean total task accuracy was determined for each condition. Using ANOVA, the differences in these means were calculated. These means were then examined for significance. Further data analysis compared each condition mean against the post-hoc information contained from the user characteristic questionnaire.

Tracked Behavior

The server log from the experiment yielded two pieces of information, the number of clicked links it took for a participant to reach the desired link and the time to reach each link. The number of links it took for a participant to navigate from the main index to the desired position was calculated. The time was also obtained and converted from minutes and seconds into seconds. The mean time and mean number of links for a participant to reach each position was obtained for each condition. This procedure was similar to Padovani and Lansdale's (2003) procedure for tracking behavior.

The time and number of links clicked for each individual to complete the experiment were also calculated. The mean time and mean number of links for a participant to complete the experiment was obtained for each condition.

Using ANOVA, the difference in these means was calculated. These means were then examined for significance. Further data analysis compared each mean against the post-hoc information contained from the user characteristic questionnaire.

Retention Test

The retention test was scored in three segments. These included the recall of the positions, the recall of the duties themselves, as well as the recognition of the true and false statements. This information was analyzed to see if the data supported or refuted hypothesis one, that those in the spatial metaphor condition would exhibit greater recall and recognition than those in the non-spatial metaphor condition.

The recall portions of the test were scored separately. Each correct answer, incorrect answer, and question left blank was individually scored. Means were calculated for each individual position from each condition. In order to test total recall of the positions and duties, each scored section of the recall portion of the retention test was then summed for each participant and means were calculated.

The recognition quiz data was also analyzed on an individual question basis. Four scores were given to each answer, including "hit," "miss," "false alarm," and "correct rejection." Each question was analyzed individually by comparing the average number of each score in both conditions using an ANOVA test. The mean of the total score for each individual participant was also compared between the two conditions.

All data from the recognition test, including individual scores and summative test results, were checked against the post-hoc data received in the user characteristic questionnaire.

Perception Data

Results from the interviews were contrasted with the subject's level of computer experience, which condition they were placed in (spatial vs. non-spatial interface) and their perceptions of the interface. Qualitative information was categorized for certain questions, including questions concerning whether the user noticed the use of the interface metaphor and if they found this metaphor helpful in navigating the site. These and other qualitative responses were discussed in detail, in order to test hypothesis two, which predicts that subjects with less computer experience will find the spatial interface more helpful than those with more computer experience. This hypothesis also suggests that subjects with more computer experience will find the metaphor less helpful.

CHAPTER IV

RESULTS

This chapter presents the data collected from the user characteristic survey and through the experimental task, the retention test, and the interview. The experimental task data includes information on the time and number of links taken to navigate to the correct link, as well as task accuracy. The retention test was also divided into two parts, a recall portion and a recognition portion. The recall portion asked participants to list the job titles they had found as a result of their search, and as many of the job duties associated with each position that they could remember. Thirty participants completed the experiment during its two-week implementation in late November and early December 2004.

Demographic Profile

The average age as well as the sex and class year indicated by the participants on the user characteristic survey can be seen in Table A1. The average age of the participants was 18.83 years of age, and in the non-spatial condition was 18.67 and in the spatial metaphor condition was 19.00 The difference in the average age of participants was found to be non-significant. Fourteen males and sixteen females participated in the experiment. Fifteen of the participants were sophomores, fourteen were freshman, and one was a junior.

Twenty-five participants indicated that their nationality was from the United States (Table A2). Although the majority of participants indicated that they had not held an on campus job (Table A3), most of the participants indicated that they had previously held an off-campus position (Table A4).

User Characteristics

Computer Use

The hours of computer use per week as indicated by the participants can be seen in Table 1.

Table 1

Computer Use of Participants

Condition	Computer Use (in hours per week)					
	0-10	11-20	21-30	31-40	41-50	51 or more
Non-Spatial Metaphor	0	4	6	3	1	1
Spatial Metaphor	3	6	6	0	0	0
Total	3	10	12	3	1	1

Operating System

The majority of participants indicated that they used Microsoft operating systems. The operating systems that participants indicated that they used can be seen in Table 2.

Table 2

Operating Systems that Participants Indicated Using

Condition	Operating System			
	Microsoft Only	Macintosh Only	Microsoft and Macintosh	Microsoft, Macintosh, & Linux
Non-Spatial Metaphor	13	1	0	1
Spatial Metaphor	11	1	2	1
Total	24	2	2	2

Internet Use

The majority of participants in the experiment indicated that they spent more than ten hours per week using the internet. Participants' indicated number of hours of internet use per week can be seen in Table 3. Several participants indicated that they had previously created and published a web page.

Table 3

Participants Internet Use (in hours per week)

Condition	Internet Use (in hours per week)			
	Never	0-10	10 or more	Created and Published a Web Page
Non-Spatial Metaphor	0	1	10	4
Spatial Metaphor	0	4	11	0
Total	0	5	21	4

Programming Ability

The majority of participants indicated that they had never programmed. The rest of the participants indicated that they were beginner programmers (having used html or had programmed a simple program), intermediate programmers (having programmed moderately complicated programs and knew one or a few programming languages quite well), or advanced programmers (having programmed relatively advanced programs, and knew several programming languages quite well) (Table 4).

Table 4

Programming Ability of Participants

Condition	Programming Ability			
	Never Programmed	Beginner	Intermediate	Advanced
Non-Spatial Metaphor	8	5	1	1
Spatial Metaphor	13	2	0	0
Total	21	7	1	1

Hypothesis One: Recall and Recognition

Hypothesis one predicted that participants who used the spatial metaphor interface would recall and recognize more information about the positions listed and their duties than those subjects who use the non-spatial metaphor interface. Analysis revealed that recall of the position titles was significantly better for those who used the spatial metaphor interface than those who used the non-spatial metaphor interface. When subjects were asked to recall the position's duties, no significant difference was found between the two conditions. Participant's average performance on the recognition test was not determined to be significantly different between the two conditions.

Recall

ANOVA was used to calculate the difference in the means of the number of positions correctly listed and incorrectly listed, as well as the mean of the number of positions left blank on the recall portion of the retention test. The means of each of these categories can be seen in Table 5.

Table 5

Mean Number of Positions Answered on the Recall Test

Condition	Mean Number of Positions Correctly Listed	Mean Number of Positions Incorrectly Listed	Mean Number of Positions Left Blank
Non-Spatial Metaphor (Index)	3.333	1.333	0.333
Spatial Metaphor (Campus)	4.133	0.867	0.000
f-value	4.996	2.399	4.374
Significance Level	0.034	0.133	0.046

From the data presented in Table 5, it was found that there was a significant difference between the mean of the number of positions correctly listed between the conditions (significance level of 0.034). A significant difference was also found in the mean number of positions left blank between the conditions (significance level of 0.046). No significant difference was found between the mean number of positions incorrectly listed between the conditions (significance level of 0.046).

Although a significant difference between the conditions was observed in the recall of the positions on the recall test, this effect was not observed for the mean number of duties recalled on the recognition test. ANOVA was used to examine the difference in the mean number of duties correctly and incorrectly listed, and the mean number of duties left blank on the recall test. The mean number of duties by condition can be observed in Table 6.

Table 6

Mean Number of Duties Listed on the Recall Test

Condition	Mean Number of Duties Correctly Listed	Mean Number of Duties Incorrectly Listed	Mean Number of Duties Left Blank
Non-Spatial Metaphor (Index)	7.9333	0.4000	16.6667
Spatial Metaphor (Campus)	9.0000	0.3333	15.6667
f-value	1.238	0.063	0.812
Significance Level	0.275	.804	.375

The difference in the mean number of duties correctly listed by participants in each condition was not significantly different (significance level of 0.275). The mean number of duties incorrectly listed was not significantly different between the two conditions (significance level of 0.804). The mean number of duties left blank was not significantly different between the two conditions (significance level of 0.375).

Recognition

The second portion of the retention test asked subjects to identify twenty statements about the positions and their duties that they had found in the task as true or false. The mean scores can be seen in Table 7.

Table 7

Mean Scores on Recognition Test by Condition

Condition	Mean Number of True or False Statements Correctly Identified	Mean Number of True or False Statements Incorrectly Identified
Non-Spatial Metaphor (Index)	17.6667	2.3333
Spatial Metaphor (Campus)	17.9333	2.0667
f-value	0.337	0.337
Significance Level	0.566	0.566

No significant difference in performance on the recognition test was found between the participants in the non-spatial metaphor condition and the spatial metaphor condition. The difference in the mean number of true or false statements correctly identified as true or false between the two conditions was insignificantly different (significance level of 0.566). The difference in the mean number of statements incorrectly identified as true or false between the two conditions was also insignificant (significance level of 0.566).

Hypothesis Two: Navigation

Hypothesis two predicted that subjects in the spatial metaphor condition would find the correct links more quickly (with less accidental clicking) than subjects who used the non-spatial metaphor condition. This hypothesis was not supported.

Table 8

Number of Links Clicked and Time to Complete the Task

Condition	Total Number of Links Clicked	Total Time
Non-Spatial Metaphor	25.1333	276.4000
Spatial Metaphor	22.6000	283.9333
f-value	0.780	0.055
Significance Level	0.385	0.816

The mean total number of links to complete the task and the mean total task time for each condition can be seen in Table 8. No significant difference between the total number of links clicked throughout the entire experiment was found between the two conditions (significance level of 0.385). There was no significant difference in the time it took to complete the experiment between the two conditions (significance level of 0.816).

Although no significant difference was found between the two conditions for the overall mean task time and the mean number links clicked, it was found that there was a significant difference in the mean time from the start of the experiment to the participants' reaching the first link. The mean number of links and mean time to reach the first position can be seen in Table 9.

Table 9

Number of Links Clicked and Time to Reach the First Position (in seconds)

Condition	Number of Links	Time (s)
Non-Spatial Metaphor	4.2667	81.1333
Spatial Metaphor	3.0000	58.6667
f-value	1.926	9.711
Significance Level	0.176	0.004

There was a significant difference in the mean time it took for participants to reach the first position between the two conditions, with subjects in the spatial metaphor condition reaching the first position 22.4666 seconds faster than those in the non-spatial metaphor condition (significance level of 0.004). Despite this difference in the mean time it took to reach the first position, the mean number of links taken to reach the position between the conditions was not significantly different (significance level of 0.176). This difference in the mean time taken to reach each position was not observed in the rest of the experiment.

Hypothesis Three: Computer Ability and Perception

Hypothesis three predicted that participants with less computer experience would find the spatial interface more helpful than those with more computer experience. Participants with more computer experience will find the metaphor less helpful.

From the interview data, there was no perceivable difference in participant's perceptions of the interface based upon condition, computer use, internet use, or programming ability. All participants in both the spatial and non-spatial metaphor conditions believed the web page they used was easy to work with. When asked how easy the interface they used was, participants in both conditions indicated that the web page was "very easy" or "extremely easy." All participants not only found the web page easy to use and clear, but also found it easy to navigate.

The only significant difference found between subjects' perception of the interface is that those with less computer and internet experience, particularly those who had never previously programmed a web page, were more likely to ask questions about how the web pages were constructed.

Additional Qualitative Data

No differences were found in the interviews between subjects in the two conditions. All participants remarked in the interview, regardless of condition, that they believed that the website they had used was similar to other simple web pages they had seen and used, and had similar navigation.

None of the participants explicitly recognized the metaphor imbedded in the interface design. One participant ventured that the metaphor may be the matching of the job description to the actual job title.

Many participants who had previously used the Ithaca College Financial Aid website remarked the website they used in this experiment was better in design. Participants felt that the position descriptions clearly reflected what they would be expected to do in such a position, and what skills and interests they should have if they were interested in applying for a position.

Overall, the participants had very few suggestions for improving the interface. Several participants in both conditions remarked that additional information such as a listing of hours and wages would be helpful. Several participants in the non-spatial metaphor condition remarked that the addition of graphics might make the webpage more exciting, however, they believed that this addition would not necessarily affect their use or their recall of the content of the website. Rather, to quote one participant, the addition of graphics to the site would "just make it more interesting if I was using it." Several participants remarked that although the addition of graphics might make the website more interesting, they were unsure of what graphics should be used.

During the debriefing, three participants who had used the non-spatial metaphor interface commented that the spatial metaphor "looked more interesting," or "looked nicer" than the interface they had used. However, these few participants did not believe that the spatial interface they saw during the debriefing would be any easier to use than the one they used, only as one participant noted, "it is nicer looking."

Significant Results Based on Participant Characteristics

Computer Use

Two significant effects were found based upon the participants' indicated hours of computer usage per week. Both of these effects demonstrated that those with less computer use per week outperformed those who used a computer for more hours per week when mean task accuracy was measured. Significant differences were also present between the different categories of computer use when the two conditions were compared for mean accuracy on finding the second position.

Table 10

Mean Total Task Accuracy by Computer Use

Condition	Mean Number of Positions Correctly Listed					
Computer Use (hours)	0-10	11-20	21-30	31-40	41-50	51 or more
	5.0000	4.8000	4.9167	4.3333	4.0000	3.0000

No significant difference was found on the mean total task accuracy by computer use between the two conditions (Table 10). However, a significant effect was found between the various categories of computer use, with those using a computer from zero to ten hours a week, eleven to twenty hours a week, and twenty-one to thirty hours a week performing significantly better than those who used a computer thirty-one to forty hours a week, forty-one to fifty hours a week, or fifty-one or more hours a week. The means for each category of computer use can be seen in Table 10. The significance level was calculated to be .000 with an f-value of 7.062.

Table 11

Mean Accuracy on Correctly Finding Link 2 by Computer Use

Condition	Mean Number of Positions Correctly Listed					
Computer Use (hours)	0-10	11-20	21-30	31-40	41-50	51 or more
Non-Spatial Metaphor (Index)	NA	1.0000	0.8333	0.6667	0.0000	0.0000
Spatial Metaphor (Campus)	1.0000	0.5000	1.0000	NA	NA	NA

A significant effect was also seen for the mean accuracy on correctly finding the second link in the task between the two conditions. Those who used a computer zero to ten hours per week and twenty-one to thirty hours per week in the spatial metaphor condition consistently found the correct link more often than those who used a computer for the same number of hours in the non-spatial metaphor condition, as can be seen in Table 11. In the non-spatial metaphor condition, participants who used a computer eleven to twenty hours a week consistently found the correct link more often than those who used a computer eleven to twenty hours per week in the spatial-metaphor condition. The calculated f-value for this difference was determined through an ANOVA calculation to be 4.346, with a significance level of 0.049.

No significant difference was found in the performance of participants due to their computer use on the recall test, the recognition test, or their performance on the task (number of links clicked or time to reach the correct link).

Operating System

One significant effect was found based upon the participants' indicated operating system on the mean total task accuracy. Participants in the spatial metaphor condition performed significantly better when their category of operating system was compared to those in the non-spatial metaphor condition, as can be seen in Table 12.

Table 12

Mean Total Task Accuracy by Operating System

Condition	Mean Number of Positions Correctly Found			
Operating System	Microsoft	Macintosh	Microsoft and Macintosh	Microsoft, Macintosh, and Linux
Non-Spatial Metaphor (Index)	4.7692	4.0000	NA	3.0000
Spatial Metaphor (Campus)	4.8182	5.0000	5.0000	5.0000

Participants who were in the spatial metaphor condition performed significantly better on the mean task accuracy when compared by what operating system they used. Consistently, Microsoft only users, Macintosh only users, Microsoft and Macintosh users, and Microsoft, Macintosh, and Linux users in the spatial metaphor were on average more accurate than those who used the same operating systems in the non-spatial metaphor condition. Using ANOVA, the f-value of this difference was found to be 5.986, with a significance level of 0.008.

Programming Ability

Two significant effects were found based upon the participants' indicated programming ability. Both of these significant effects demonstrated that those with less programming experience outperformed those that those who indicated greater programming ability when the mean task accuracy was measured. Significant differences were also present when the recall of position titles was measured.

Those who identified themselves as having no or beginner-level programming experience as a group performed significantly better on the mean task accuracy than those who identified themselves as intermediate or advanced programmers. The mean total task accuracy by programming ability can be seen in Table 13.

Table 13

Mean Total Task Accuracy by Programming Ability

Condition	Mean Number of Positions Correctly Found			
Programming Ability	None	Beginner	Intermediate	Advanced
	4.8095	4.8571	4.0000	3.0000
Number of Participants	21	7	1	1

Using ANOVA, the f-value for this difference was calculated to be 7.981, with a significance level of .001. This effect may be partly due to the fact that more participants indicated that they had never programmed or were beginners than intermediate and advanced programmers.

When the categories of computer programming ability were examined between the two conditions this effect was found to be insignificant. Those in the spatial metaphor condition within each category of computer programming ability performed no better than those in the non-spatial metaphor condition.

A second effect of programming ability was also found on the recall test when the participants were asked to list the position names they remembered from the task (Table 14).

Table 14

Mean Positions Correctly Listed on Recall Test by Programming Ability

Condition	Mean Number of Positions Correctly Found			
Programming Ability	None	Beginner	Intermediate	Advanced
	4.0476	3.4286	1.0000	2.0000
Number of Participants	21	7	1	1

Those who identified themselves as having no computer programming experience performed significantly better on the recall test when they were asked to list the job titles that they had previously searched for than those who identified themselves as being beginner, intermediate or advanced programmers, as can be seen in Table 14. Using ANOVA, the f-value of this difference in those answered on the recall test was calculated to be 6.129, with a significance level of 0.003. There was no significant difference in the mean number of positions correctly listed for each category of programming ability when participants in the two conditions were compared.

Internet Use

Subjects who indicated that they used the internet less than ten hours per week performed significantly better on the task than those who used the internet for more than ten hours per week, or had previously created and published a webpage, as can be seen in Table 15.

Table 15

Total Task Accuracy by Internet Use

Condition	Mean Number of Positions Correctly Found			
Internet Use (in hours)	None	Less than 10	More than 10	Published
	NA	5.0000	4.8095	4.0000
Number of Participants	NA	5	21	4

Using ANOVA, the f-value for this difference 6.775, with a significance level of 0.004.

Non-Significant Differences

There was no significant difference found in the performance of participants due to their age, sex, class year, nationality, or application use, on the recall test, the recognition test, or their performance on the task (number of links clicked, time to reach the correct link, or task accuracy). Significant differences were not observed based upon a participants' work history, including if they had held an on or off-campus position, the type of position they had held, or if they had previously used the Ithaca College Financial Aid Website job search.

CHAPTER IV

DISCUSSION

This chapter discusses the significant results that were overviewed in the previous chapter. This includes a discussion of the three hypotheses, information from the interviews, as well as significant results from the post hoc analysis. Finally, the limitations of this study are discussed.

Hypothesis One: Recall and Recognition

Hypothesis one predicted that participants who used the spatial metaphor interface would recall and recognize more information about the positions listed and their duties than participants who use the non-spatial metaphor interface.

Position Title Recall

A significant difference was found between the two conditions when participants were asked to recall the positions they had recorded during the task (Table 5). Participants in the spatial metaphor condition remembered, on average, one more position than those in the non-spatial metaphor interface condition. This difference in position recall suggests that those participants in the spatial condition remembered more information from the interface. This finding is supported by much of the theory on metaphor and its role in learning and theory based upon spatial interaction, as well as theories about disorientation and cognitive load in web-based systems.

This finding suggests that the spatial metaphor was more effective as a mediator between learning the position titles and using the interface; the non-spatial metaphor was not as effective. This finding also suggests a strong correlational relationship between the spatial metaphor and the related cognitive image schema. This relationship may have allowed better performance on the recall task: users demonstrated higher recall due to having a stronger mediator of the spatial metaphor.

The spatial metaphor of the Ithaca College campus that was used in this experiment may have been a strong mediator because of its cultural relevance and familiarity to students. Previous studies have shown that a user's culture is important in creating effective metaphor-based interfaces (Choong & Salvendy, 1999). It is likely that the Ithaca College students who participated in this experiment would be familiar with the campus. By choosing a metaphor that is culturally relevant to the participants, it is more likely to serve as a strong mediator. This increases the chances that the metaphor will allow new information to be mapped to an existing image schema (Lakoff, 1990). In the case of this study, participants may have had an existing image schema of the spatial layout of the campus. This spatial metaphor acted as a mediator between their existing knowledge and the new knowledge they were learning about the position titles.

People interact with space in their daily lives (Carroll, Mack, & Kellog, 1988; Erickson, 1993; Kuhn & Frank, 1991). It is important that people not only know what they are looking for but also where they can find information (Jones & Dumais, 1986). It is likely that as Ithaca College students, the participants interacted with the spatial layout of the campus daily. This knowledge of the spatial layout of the campus may have helped participants to recall the positions because they could more easily visualize the campus, as well as the internal layout of the buildings.

One of the main problems of using the internet is user disorientation. Two of the major symptoms of disorientation could have been alleviated through the use of the spatial metaphor: the user does not know where to navigate next and the user does not know where they are in relation to the rest of the document (Edwards & Hardman, 1989). By taking advantage of a spatial metaphor with which the participants interacted daily, it is less likely that a user will become disorientated. The participants in this study had interacted with the metaphor of the spatial campus on a regular basis, and this previous interaction as well as their knowledge about the spatial layout may have helped them to more effectively navigate the interface without becoming disorientated. Disorientation in a web page can lead to cognitive overload. Cognitive overload can lead to poor recall (Teigen, 1994).

The spatial metaphor may have also provided a context for the task of searching for job positions, thereby decreasing the amount of cognitive load that the user experienced. Context is an important cue to internet users that helps them to effectively navigate web pages (Gygi, 1990). High levels of cognitive load can negatively affect a user's short-term and working memory (Teigen, 1994). By reducing the amount of cognitive load associated with using the web pages, the spatial metaphor may have improved participants' recall of the positions.

Position Duty Recall

There was no significant difference found between the two conditions when participants were asked to recall duties associated with each position (Table 6). It is possible that the non-significant results seen in the recall for the position duties is due to their purely textual format. Duties were listed in text, and were seen on the right section of the screen in both conditions. Since the listing of position duties was not spatially organized, it is possible that any recall advantages in the spatial metaphor condition would not be transferred to the position duties, which were not spatially organized. It has been suggested that for metaphors to be effective in interface design, these metaphors must be embodied in as much of the interface as possible (Erickson, 1990). Previous studies that have demonstrated significant effects between spatial and non-spatial interfaces have not incorporated non-spatial textual elements into their design and therefore have not tested the retention or interaction effects of including these elements (Kim, 1999; Padovani & Lansdale, 2003).

Previous research has shown that text must be highly organized in order to provide the reader with effective logical visual cues. These cues include transferring headings, subsections, and other organizational cues from a paper-based document onto a computer interface. Effectively using these cues, and relating the visual appearance of text to the document structure, prevents users from being overwhelmed with text-only web pages (Southall, 1989). Providing users with such visual cues also prevents one of the most common consequences of cognitive overload: the user does not know where they are in a document (Edwards & Hardman, 1989). It is quite possible that in this experiment, the text available in this part of the user interface was not logically structured with appropriate headings or substructures. If the text was not logically structured, then this could lead to cognitive overload. If users must spend more of their cognitive resources navigating a difficult document, less of their cognitive resources can be dedicated to learning new information. Therefore, cognitive overload can lead to poor task completion and poor recall (Teigen, 1994).

Recognition of Position Titles and Duties

Hypothesis one predicted that there would be a significant difference in recognition between the two conditions. This hypothesis was rejected, as no significant difference in performance on the recognition part of the retention test was observed (Table 7).

This hypothesis may have not been supported due to the differences in the types of memory associated with recall and recognition, in that recognition does not require the same intensive level of memory as recall (Shapiro, 1994). Recognition is the most sensitive level of memory, because the item to be recognized is presented to the participant. Recognition indicates whether a piece of information was encoded (Tulving, 1972; Tulving & Thompson, 1973). Recall indicates whether a participant can retrieve the encoded information (Lang, 2000). This suggests that both the spatial and non-spatial interfaces were able to promote participant's encoding of the information presented, whereas the spatial metaphor induced greater retrieval of the information.

It is possible that the non-spatial index metaphor, while it did not act as a strong mediator between the relevant image schema and the new information to promote recall, served as a weak mediator. As a weak mediator, the metaphor may have enabled the participants to encode the information, as evidenced by the recognition test, but this weak mediator did not promote retrieval.

Hypothesis Two: Navigation

Hypothesis two predicted a significant difference between the participants' navigation of the spatial and non-spatial metaphor conditions. Previous research has suggested that spatial metaphors decrease both the amount of time it takes to navigate to the correct link as well as accidental clicking (Kim, 1990; Padovani & Lansdale, 2003). This hypothesis was rejected; no significant difference was found between the two conditions for the time it took to navigate throughout the entire experiment or the number of links clicked throughout the entire experiment (Table 8).

Spatial metaphors have been found to decrease navigation time and promote efficiency by decreasing the number of links clicked to reach a desired link (Padovani & Lansdale, 2003; Kim, 1999). However, Padovani and Lansdale (2003) did not design parallel tasks for the non-spatial and spatial interface metaphors. It is entirely possible that the level of difficulty embodied in these two tasks was different, and therefore led to differences in navigation performance. It is possible that spatial metaphors do not truly increase navigational efficiency, as demonstrated in this study, if participants complete a similar task in both the spatial and non-spatial metaphor conditions.

A second possibility for the non-significant differences in navigation between the two conditions is the computer ability of users. Spatial metaphors, and interface metaphors in general, are thought to help novice users to more effectively navigate a website (Carroll & Thomas, 1982). Since the sample that was examined in this study was lower-level college students, it is possible that they have a better understanding of how the internet and computers function than novices. This greater understanding would suggest that the metaphors would not necessarily promote more efficient navigation. Some theorists suggest that metaphors may even interfere with advanced users effectively using an interface (Marx, 1994).

Navigating to the First Link

Although no significant effect was found when comparing the overall number of links and time it took for participants to complete the experiment, a significant difference was observed when the amount of time to reach the first link was measured between the two conditions (Table 9). Participants in the spatial metaphor condition found the first link 22.4666 seconds faster on average than those in the non-spatial metaphor condition, although the number of clicks to reach the desired first link was the same between the two conditions.

It is possible that the spatial metaphor did convey a better understanding of the underlying site structure than the non-spatial metaphor, but as participants moved through the task, their working memory was overloaded with further information from the website they were using, which slowed navigation time and increased the number of links necessary to find the desired position. Cognitive overload has been shown to contribute to a users' inability to complete a task, or their inability to complete a task in an efficient manner (Teigen, 1994).

Previous studies have focused solely on information seeking and the majority of the participants' tasks involved finding items and not reading descriptions or other information about the items (Padovani & Lansdale, 2003; Kim, 1999). It is possible that asking participants to read this additional information associated with searching for an on-campus position overloaded their short-term and working memory, which may have slowed their navigation time throughout the rest of the experiment. Since subjects were asked to read the same information in both conditions, it is possible that any positive effects seen in the spatial metaphor condition may have been cancelled out by the cognitive overload inherent in the system. Prior to clicking on the first link, the amount of information presented in a text-format was minimal, whereas after the first link, the amount of information a participant examined became much greater.

Hypothesis Three: Computer Use and Perceptions

Hypothesis three suggested that subjects with less computer use would find the spatial metaphor more helpful than those with more computer experience. This hypothesis was rejected. Participants with less computer and internet usage, less application use, and less programming experience did not find the spatial metaphor more helpful than those with the same levels of usage and ability in the non-spatial metaphor interface.

It has been suggested that metaphors would be particularly helpful to users who have less accurate models of applications they use. Advanced computer users, who have more accurate mental models, are thought to find these metaphors less helpful. These metaphors could even interfere with an advanced user effectively using an interface (Carroll, et al., 1988).

All participants, regardless of condition, found the interface they used to be relatively easy to navigate. When asked how easy the interface was to navigate, the majority of users replied that the interface was “very easy” or “extremely easy.” None of the participants in either condition indicated any problems or difficulties when using the system. This finding suggests that users with less computer, internet, and programming experience did not find the spatial metaphor more helpful than those with the same level of experience in the non-spatial condition. It is possible that even those with less experience had sufficiently accurate mental models of web interfaces to complete the task with relative ease. Previous research has suggested that the majority of college-level students are extremely familiar with the web and web pages in general, due to exposure in college or during secondary education (Jones, 2002).

The majority of participants also conveyed that the interface was “very similar” or “the same” as many web pages they had used previously. The users experience with using similar web pages may have also helped them to create better mental models of the system they were using.

Only a small portion of the participants indicated that they had intermediate (one participant) or advanced (one participant) programming skills. It is possible that these participants were not representative of the population that would typically identify themselves as intermediate or advanced programmers. Previous studies have not addressed user perceptions in regard to computer and internet ability, and very few studies have examined computer and internet ability in relation to metaphoric interface design.

User Perception of the Interface

No differences were found in the interview results between the participants in either condition. The interview asked participants about their general perceptions of the website, including ease of use, problems encountered, what they believed worked well in the interface, and how they felt while using the interface.

All of the participants indicated that they encountered no problems while using the interface. The majority of participants indicated that they found that the interface they used was well designed, easy to use, and easy to navigate. The majority of participants indicated that the interface was “very easy” while the others indicated that the interface was "easy" to use. All participants indicated that they felt "good" or "enjoyed" using the interface when asked how using the interface made them feel. This finding is in stark contrast to Sutcliffe et al. (2000) who found that a spatial interface was preferred to a non-spatial interface. However, in their work, they observed that task accuracy was significantly decreased for participants who used a spatially designed interface. Such a finding was not observed in this study, and task accuracy was very similar between participants in the spatial and non-spatial interface conditions. In the Sutcliffe et al. study participants were asked to complete a task centered on a subject matter that was unfamiliar to them, searching for literature that was unrelated to their field of study. Participants' unfamiliarity with the subject matter may have made the spatial metaphor feel more reassuring and helpful than the interface that was designed around a non-spatial metaphor. Interface metaphors are believed to reduce confusion, and therefore reduce user frustration for first time users of a system (Barbosa & de Souza, 2001). In this study, the majority of participants indicated that they had actively searched for an on-campus position, or had friends or classmates who had done so. The participants' familiarity with campus positions, or the task of searching for an on-campus position, may have made the task easier for participants, and therefore made the reassurance of using a spatial metaphor less visible.

The majority of participants indicated that the web page they had used was "very similar to," "similar to," or "the same as" other web pages that they had encountered through web surfing. The only comment that differed between the two conditions is that many participants in the non-spatial condition indicated that the pages they had used had no graphics. The only suggestions for improvement of the interface involved content changes and the addition of graphics. Two participants, one in the spatial metaphor condition and one in the non-spatial metaphor condition, indicated that they believed content changes would make the interface more effective. These content changes included listing how many hours per week and the hourly rate for each job, as well as contact information for the supervisor who was responsible for hiring students.

Three participants indicated that they believed that the non-spatial interface could be improved through the addition of graphics. One participant questioned what type of graphics could be effectively used to make the pages more interesting:

> I think more graphics would make the page… look more… nice, I guess. But I don't think they are necessary, besides, I don't know what types of pictures you would use, maybe some photos of people doing stuff… doing the types of jobs you show? But I don't think it would make the page work any better, I don't really know much about web stuff.

This questioning of appropriate graphics also indicates the level of familiarity with internet. The participant quoted above indicated that he was not very familiar with web design. This unfamiliarity with effective web design may be indicative of why so few comments were offered to improve the interface.

None of the participants in the spatial or non-spatial metaphor condition recognized that a metaphor was being used in the interface they were using. This may be due to a loss of interface metaphors' referent ability. Theorists have suggested that many metaphors die, losing their referent ability, and become everyday idioms of speech. These metaphors are no longer recognized as metaphors, but rather become common parts of our everyday language and thought (Stubblefield, 1998). It is possible, because of the commonality of metaphors in many aspects of interface design, that interface metaphors are no longer recognized. During the debriefing, many participants indicated that they no longer recognized one of the most pervasive metaphors in interface design, the computer desktop. Participants overwhelming indicated that they did not know that the computer interface desktop was an interface metaphor and had never associated the interface desktop with a physical desktop.

Several participants who used the non-spatial metaphor indicated during the debriefing that the spatial metaphor "looked more interesting" or "looked nicer" than the interface they had used. These comments suggest that even though participants may enjoy using non-spatial interfaces, they may think that spatial interfaces are more visually pleasing to work with. These comments may have been due to the non-spatial interface's lack of graphics. As one participant commented, the spatial metaphor interface was "nicer looking." All three participants who commented on the visual appeal of the spatial metaphor did not think that the visual display of the interface would have made their navigation of the interface more efficient or would have made the web pages easier to use. All of the non-spatial participants who made comments on the visual appeal of the spatial condition agreed that the use of the graphics might have made the task more enjoyable.

Other Significant Results from Post Hoc Data Analysis

Significant results were only found for the following categories: computer use, operating system, programming ability, and internet use.

Computer Use

Total Task Accuracy and Computer Use

A significant difference was found among participants who indicated that they used a computer for fewer hours per week than those who used a computer for more hours per week when the mean total task accuracy was measured (Table 10). Total task accuracy was defined as the number of positions that a participant correctly listed on the task answer sheet. Those who indicated that they used a computer from zero to ten hours a week, eleven to twenty hours a week, and twenty-one to thirty hours a week performed significantly better than those who used a computer thirty-one to forty hours a week, forty-one to fifty hours a week, or fifty-one or more hours a week.

It is possible that these findings reflect the interference that many theorists have predicted occurs when advanced users use a metaphor-based interface. Metaphors are thought to help users who have limited knowledge of the applications they are using, and therefore have poor mental models (Pouts-Lajus et al., 1996). Since both interfaces were based upon a metaphor, it is possible that both metaphors interfered with or frustrated users who used a computer more often. However, there was no indication from the interview that any participants found the system hard to use, or were frustrated while using it. However, this information from the interview was self-reported and only asked about emotions of which users were consciously aware. More advanced users may have been unconsciously frustrated with the interface, or were consciously frustrated with the interface but did not want to voice their opinions with the researcher. Many participants' suggested through their language use that they believed the researcher to be the designer of the site. Some participants may have not wanted to verbalize their frustrations to the person they believed had designed the site.

A second possible explanation for the decreased task performance that is observed in participants who self reported greater computer use is how participants allocated their computer use time. Participants who indicated greater computer usage may not necessarily possess more accurate models of how computer applications work. This increased time could be influenced by the participant's workload, or could be divided among any number of applications, which may not be internet based, and therefore would not increase participants understanding and create a better mental model of the internet and how it functions. Finally, a person with greater hours of computer usage may simply use more computer time because they do not possess accurate mental models of the applications they use, and therefore struggle using these applications. Since the amount of computer usage was self-reported by the participants, it is also possible that several of the participants over or under estimated their computer usage, which could affect the results.

Task Accuracy on the Second Position and Computer Use

A significant difference was found between participants in the two interfaces when the mean task accuracy of finding the second position was compared to their reported hours of computer use per week. Participants who used a computer zero to ten hours per week and twenty-one to thirty hours per week in the spatial metaphor condition consistently found the correct link more often than those who used a computer for the same number of hours in the non-spatial metaphor condition (Table 11). In the non-spatial metaphor condition, participants who used a computer eleven to twenty hours a week consistently found the correct link more often than those who used a computer eleven to twenty hours per week in the spatial-metaphor condition.

In order to find the correct position that matched the second position's description, users were faced with two positions for which duties in the physical world may have been very similar. The correct answer involved indicating the Cashier position. The Bursar Assistant position was the most commonly mistaken position. Although these two positions had very different descriptions, one descriptor in both positions matched one part of the description that participants were asked to find. Participants had to carefully read the description they were given in order to correctly identify the Cashier position. Since the users were participating in an experiment, it is unlikely that they read the descriptions as carefully as they would if they were truly searching for a campus position.

As can be observed from the navigational tracking records, the majority of participants first investigated the Bursar Assistant position before searching more extensively for the correct position of Cashier. Whereas most of the participants in the spatial condition continued searching until they reached the Cashier position, three participants in the non-spatial metaphor condition stopped searching once they reached the bursar position, and one continued searching for the correct position, and eventually navigated back to the incorrect Bursar Assistant position.

There are several explanations for this finding. The first is that computer users who used a computer for greater amounts of time found working with either metaphor (spatial or non-spatial) frustrating, and eventually chose the wrong position due to frustration with the interface. It is possible, as suggested by the literature, that the use of these interface models interfered with advanced computer users accurately completing the task (Marx, 1994). However, even users who identified the incorrect answer for the second position reported no problems using the system and reported that they used the system with relevant ease. No users responded with a negative or even neutral response when asked about how they felt while using the interface and searching for positions. This suggests that users, even those who used a computer for many hours, were not acutely aware of any frustrations that they felt while using the system during the interview.

A second explanation is that users, depending on their level of computer ability, had varying degrees of involvement in the task. Cognitive load theory suggests that if the user is faced with a cognitive load that is too low, they will likely perform poorly on a task (Teigen, 1994). It is possible that participants with greater computer time had more accurate mental models of the internet, and due to low cognitive load, were less involved in the task and therefore had poorer performance.

As stated previously, this difference in task accuracy for finding the second position could purely be due to discrepancies in participant self reporting of their computer usage, how and what applications a participant interacts with, and their computer competency.

The most interesting aspect of this finding was that participants in the spatial condition who indicated that they spent eleven to twenty hours per week using a computer performed significantly poorer on task accuracy than those participants with the same amount of computer usage in the non-spatial metaphor interface. Users in this computer use category in the spatial metaphor may have had accurate enough mental models to allow them to effectively navigate a web page without the assistance of a spatial metaphor. If this is true, the spatial metaphor may have interfered with their ability to effectively navigate a web page, even if this interference did not lead to frustrations that were voiced during the interview.

Operating System

Total Task Accuracy by Operating System

The only significant finding based upon a user's operating system was in the total task accuracy (Table 12). Participants who indicated that they only used Microsoft based operating systems, Macintosh-based systems, and Linux, Microsoft and Macintosh based operating systems performed significantly better in the spatial metaphor condition than those who used the same operating systems in the non-spatial metaphor condition. In the case of the Microsoft based operating systems, the performance of participants in the spatial metaphor condition was only slightly more accurate than those in the non-spatial metaphor condition.

No previous studies have addressed operating system use and its effects on user accuracy in metaphor-based interfaces. However, this finding suggests that if users of operating systems are compared using spatial and non-spatial interfaces, users within each operating system category will have greater task accuracy if they are using a spatial interface.

Programming Ability

Total Task Accuracy by Programming Ability

A significant difference was observed between the varying levels of programming ability and the total task accuracy (Table 13). This effect was not observed between the two conditions, but rather total task accuracy was greater for participants who indicated that they had never programmed (no programming experience), or had programmed simple web pages (beginner level programmer) regardless of the condition in which they were placed. Participants who indicated that they knew a few different programming languages (intermediate level programmer) or knew several programming languages extremely well (advanced level programmer) performed less well in both the spatial and non-spatial conditions.

This finding was most likely due to the number of participants who indicated their programming ability in each category. The majority of participants indicated that they were either beginners (twenty-one participants) or beginner programmers (seven participants). Only one participant indicated that she was an intermediate programmer and one participant indicated that they were an advanced programmer. Since the majority of participants indicated that they either had no programming experience or were beginner programmers, it is likely that this significant result is due purely to individual differences. In the no programming experience and beginner categories, individual differences between performance were more likely to be masked due to the number of participants involved. In the intermediate and advanced programming categories, individual differences were magnified, due to the small number of these participants who indicated these levels of computer ability.

Mean Number of Positions Correctly Listed on Recall Test

A significant difference was also found between the different levels of programming ability and the number of positions that were correctly listed on the recall test (Table 14). This effect was not observed between the two conditions, but rather the recall of positions was greater for participants who indicated that they had never programmed (no programming experience), or had programmed simple web pages (beginner level programmer) despite which condition they were placed in. Participants who indicated that they knew a few different programming languages (intermediate level programmer) or knew several programming languages extremely well (advanced level programmer) performed more poorly, in both the spatial and non-spatial conditions.

As discussed above, the differences seen between advanced and intermediate programmers and those who indicated that they were a beginner programmer or that they had no previous programming experience may have been due to the majority of participants indicating that they were beginner programmers or had no programming experience, which may have masked individual differences.

The more significant part of this finding was the differences in the number of positions correctly recalled between those who indicated that they were beginner programmers or had no previous experience. Those who indicated that they had never programmed, on average, recalled 0.6190 of a position more than those who indicated that they were beginner programmers. This finding suggests both the spatial and non-spatial metaphoric interfaces significantly increased recall of the position titles for participants who never had designed a web page or previously programmed. This finding correlates with much of the research that suggests that those who have poorer mental models of the systems they are using are more likely to be helped by correctly designed interface metaphors than by non-metaphoric interfaces. It is likely that those who have never created or published a web page are more likely to have poor mental models of the internet, and are likely to lack a fundamental understanding of the node and functional aspects of the internet (Pouts-Lajus et al., 1996).

In this discussion of programming ability, mental models, and metaphoric interfaces, it is important to remember the significant finding regarding the differences in recall based upon condition. As previously discussed a significant difference was found between the recall of all participants dependent upon the interface that they used. Participants in the spatial metaphor condition remembered, on average, one more position than those in the non-spatial metaphor condition. Although this finding suggests that for those who have no programming experience any metaphoric interface, be it spatial or non-spatial, will help their recall of position titles, the majority of participants recalled more positions in the spatial condition. This finding suggests that for a wide-range of programming abilities and other user characteristics, spatial interfaces increase recall. A major concern for designers, as reflected in this finding, is that the choice of a metaphor during the design of an interface should be based upon potential user characteristics (Erickson, 1990).

Internet Use

Total Task Accuracy by Internet Use

Participants who indicated that they used the internet for less than ten hours per week performed significantly better on the total task accuracy than those who reported that they used the internet more than ten hours per week or had previously created and published a web page (Table 15). Participants who indicated that they had used the internet less than ten hours per week correctly found all five positions, regardless of condition. A significant difference was not observed for the various categories of internet use based upon condition.

This finding suggests that those who used the internet less than ten hours per week found both the spatial and non-spatial metaphors helpful in correctly finding all the positions in the interface. Previous literature has suggested that those who are likely to have poorer mental models of the systems they are using are more likely to be helped by correctly designed interface metaphors than by non-metaphoric interfaces. It is likely that those who have never created or published a web page or who do not spend a significant amount of their time on the internet are more likely to have poor mental models of the internet, its functionality, and structure (Pouts-Lajus et al., 1996). This finding suggests that any carefully designed metaphor, spatial or non-spatial, is likely to increase the task accuracy of those who use the internet less than ten hours per week. For those who used the internet more than ten hours per week a slight decrease in task accuracy was observed, but this finding could be due to the greater number of participants who indicated that they spent more than ten hours per week on the internet.

Those who stated that they had created and published a web page, on average, did not correctly identify one less position than those who indicated that they used the internet less than ten hours per week. This may be due to the metaphors chosen interfering with the accuracy of more advanced internet users.

Limitations

There are several limitations to this study. The first is its relatively small sample size. Although this study used thirty participants, and many previous studies had similar sample sizes, it is unlikely that the sample accurately reflects all users. Since a convenience sample of lower-level psychology students was used, it is likely that there was some bias in the sample. It is unlikely that these psychology students are representative of the typical users in age, background, socio-economic class, educational level, and familiarity with the internet. This bias limits the ability to extrapolate these findings to the general population.

A second limitation is that the task is not similar to one that would be used in an e-learning application. The task of searching for on-campus jobs is not likely to be a task that would require recall or recognition of items searched. Searching for on-campus jobs was chosen, as it was believed to be relevant for the participants in this study, regardless of major or field of study. Irrelevant tasks have been shown to decrease learning and to limit task involvement, which can affect memory and task performance.

A third limitation is the layout of the campus that was chosen for use in the spatial metaphor interface. The image that was used was the only readily available image provided by Ithaca College. One participant indicated in the debriefing that the spatial layout of the campus provided in the spatial metaphor condition was not similar to what he visualized as the spatial layout. Since he lived to the west of the campus, he always visualized the layout of the campus from the opposite direction in which it was presented. In the image presented, the campus tower buildings were oriented to the top and back of the interface. Due to where this participant lived, he stated that in his visualization of the campus, he would orientate the towers at the bottom and front of the interface. Unfortunately, this participant was encountered near the end of the study; so further participants could not be interviewed to determine if other participants viewed the campus in a similar matter. As a result of this limitation, it is possible that many participants found that the campus was orientated in the incorrect direction, and therefore had difficulties navigating the interface at this level. This difference in orientational perspective among participants may have accounted for similar navigation times between the participants in the spatial and non-spatial conditions. Studies that demonstrate similar navigation efficiencies between spatial and non-spatial metaphoric interfaces have not previously been reported.

A fourth limitation is that the participants who were observed in the experiment were all reasonably familiar with the internet and using a computer as college students. No students displayed discomfort at being asked to work with a computer, or to search a web page for relevant information. Although the literature does not specifically define novice users when it discusses poor mental models of applications, it is possible that those students who were defined as novices in this experiment are not what most designers consider to be novice computer or internet users. The majority of college students are required to work with computers and the internet for their coursework. A significant percentage of college students also report that they had exposure to computers previous to entering college in secondary education, primary education, or at home (Jones, 2002).

A final limitation of the study presented is the fact that the data obtained from the user characteristic survey was self-reported. Participants may have misjudged how many hours they use a computer or the internet.

CHAPTER VI

CONCLUSION

In summary, this study examined several aspects of spatial and non-spatial metaphors in interface design. Previous studies had demonstrated that spatial metaphors, when compared to non-spatial metaphors, decreased navigation time (Kim, 1999; Pandovani & Lansdale, 2003). Other studies demonstrated that users preferred spatially designed interfaces, even when their performance on a task was poor.

It was found that spatial metaphors increased recall of information presented in an interface at a significantly higher rate than non-spatial metaphors. Recognition of the information presented in the interface was the same between the two conditions. No significant differences were found in the navigation of participants when the spatial and non-spatial interfaces were compared. From the interviews, it was determined that users found both the spatial and non-spatial interfaces easy to use and navigate, regardless of their computer and internet experience.

Recommendations and Contributions

Based upon the findings of this study, several recommendations can be made for designers of metaphor-based interfaces.

This study demonstrated that spatial interface metaphors increase users' recall of information displayed in a spatial interface. However, this study also demonstrates that users' recognition of information that is presented in a spatial interface is not greater than users' recognition of information presented in a non-spatial interface. This finding suggests that in certain e-learning applications, spatial metaphors may be helpful if the designer hopes to increase recall, while non-spatial metaphors are as helpful in promoting recognition of information as spatial metaphor interfaces. With this finding in mind, a potential designer could choose an interface metaphor based upon what level of learning they wish to access.

This study, by having participants undertake parallel tasks in a website that had the same underlying structure for both the non-spatial and spatial condition, was able to demonstrate that participants showed no differences on navigational efficiency when they worked with a spatial or non-spatial metaphoric interface. This is a significant finding in that it challenges much of the previous research on spatial metaphors. Using similar parallel tasks must be investigated further in future research. This study suggests that the traditional design of experiments that explore spatial and non-spatial interfaces must be rethought.

This study examined user perceptions of spatial and non-spatial metaphor interfaces, and determined that the participants interviewed were satisfied with the both the spatial and non-spatial interfaces. Users also did not recognize the metaphors embodied in either of these interfaces, which suggests that many interface metaphors have lost their referent ability. Further study should explore users' perceptions in greater depth, and designers should account for these preferences when designing interfaces for web-based systems.

A final important insight of this study is its support for other research findings that several aspects of its participants' characteristics affect user performance. This study's findings strongly supports previous claims made by several researchers that it is important to consider user characteristics when designing an interface (Erickson, 1990;

Carroll & Thompson, 1982). Participants who reported lower amounts of computer use, internet use, and lower levels of programming ability tended to perform better on total task accuracy regardless of condition. This suggests that any metaphor-based interface would effectively increase task accuracy for these groups. Participants, when compared on the basis of the operating system they used, tended to perform better on task accuracy when provided with a spatial metaphor interface. These findings especially support that novice users, who may have poor mental models of the applications they are using, find metaphor-based interfaces helpful in completing a task (Carroll & Thompson, 1982; Marx, 1994). Significant differences found in these aspects of performance based upon user characteristics can suggest which type of metaphor, spatial or non-spatial, would be most effective when creating e-learning for these particular user populations.

Further Study

There are several opportunities for further study in spatial and non-spatial metaphor interface design. These include further study with a larger and more diverse population and with more relevant learning tasks. Further research should also address how spatial metaphors act as mediators between old and new knowledge and metaphor's effects on cognitive load. Further research could also examine user preference for spatial and non-spatial interfaces, the use of spatial and non-spatial metaphors among novice users, their use in other applications, such as PDAs, and the interactions between metaphorical and non-metaphorical elements.

One of the greatest advantages of using metaphors in interface design is that they are thought to make applications easier to use for novices (Carroll & Thomas, 1982). Further study should look at more culturally diverse segments of the population, as metaphors are culturally bound (Marcus, 1998). By further exploring novice computer and internet user populations, as well as culturally diverse populations, spatial and non-spatial metaphors can be examined for their appropriateness in these user populations.

Additional investigation of the use of spatial and non-spatial interfaces should examine their applicability and effectiveness on other pertinent learning tasks outside of the academic education realm. Do the results found in this study extrapolate to other learning activities? Such investigations should examine a large range of learning activities that are computer based both in educational institutions and in the workforce.

Further study should also examine the mediating effects of metaphors in learning. The findings in this paper suggest that spatial metaphors act as better mediators for recall, whereas both spatial and non-spatial metaphor aid in recognition. The nature of the process of mediation via metaphor should be investigated, including how spatial metaphors act as mediators and under which conditions this mediation is optimized.

This study has also found that spatial interface metaphors increase recall of elements in the interface that are displayed spatially. Users' recall and recognition of information in interfaces that include both spatial and non-spatial or textual elements should be examined. Future research should also focus on the effects of spatial and non-spatial interface metaphors on cognitive load, as well as their potential to influence orientating responses. The amount of information that a user can attend to and store in memory is controlled by the user's processing resources. Any medium, by virtue of its structure and content, controls a user's automatic allocation of processing resources. This control of processing resources occurs through orienting responses, which are attentional, reflexive, and automatic responses to stimuli or changes in the environment (Lang, Borse, Wise, & David, 2002). Metaphors potential in increasing a user's processing resources through orientation must be examined further.

Future research should seek to generate more knowledge about user preferences and their relation to spatial and non-spatial interfaces. In this study, participants did not demonstrate a significant preference for one interface metaphor. Further studies should examine which types of interface metaphors users prefer for certain applications.

Based upon this study, future research should investigate the use of spatial and non-spatial metaphors in other interfaces outside of the e-learning domain. There are many applications for which spatial or non-spatial interfaces could prove effective. The creation of small, portable devices, such as PDAs and microcomputers brings several challenges to the field of interface design. These devices, despite being portable and having a large amount of processing capability, are limited because of their small screen size (Myers, Hudson, & Pausch, 2000). New investigation should examine how spatial and non-spatial metaphors can help users to deal with the unique challenges that using such systems entail.

Finally, this study demonstrated a significant difference in user recall of elements that were organized spatially compared to textually organized elements. Non-metaphoric elements that should be addressed in the future include textual elements and graphical elements. Future study should focus on these interactions between metaphorical and non-metaphorical elements, in regards to recall and recognition, which have not been previously examined.

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APPENDIX A
SUBJECT CHARACTERISTIC SURVEY

Identification Number: ______________________ (would be filled in by researcher)

Please fill out the information below:

Age: _______

Sex: Male or Female

College Year:

Freshman Sophomore Junior Senior Graduate

Nationality: ______________________

Computer Use

How often do you use a computer? (Please circle which range applies):

0-10 hours per week

11-20 hours per week

21-30 hours per week

31-40 hours per week

41-50 hours per week

51 or more hours per week

Application Use:

What applications do you use? (Please circle all that apply):

Internet

Email

Word Processing Software (Such as Microsoft Word)

Spreadsheet Software (such as Excel)

Graphic Software (such as Photoshop)

HTML editors (such as Dreamweaver)

SPSS

Other: (please specify): ______________________

Operating System:

Please circle all the operating systems you use:

Microsoft Windows (PC based)

Macintosh/ Apple (Mac based)

Linux

Internet Use:

What is your level of internet ability? (Please Circle One)

None- I have never used the internet.

I use the internet occasionally, 0-10 hours per week.

I spend a significant amount of my time on the internet, 10 hours or more per week.

I have created and published a webpage using html or an html editor (such as Dreamweaver).

Programming Ability

What is your level of programming ability? (Please circle one)

<u>None</u>- I have never programmed.

<u>Beginner</u>- I would consider myself to be a novice programmer. I can program simple programs or create web pages using html.

<u>Intermediate</u>- I would consider myself to be an intermediate programmer. I can program relatively advanced programs. I know a one or a few programming languages quite well.

<u>Advanced</u>- I would consider myself to be an advanced programmer. I can program highly advanced programs, and I am very familiar with several programming languages.

Work Experience

Have you held a job on campus? Yes or No

Have you held a job off campus? Yes or No

Have you used the Financial Aid's Student Employment website? Yes or No

If you have previously held a job on campus, please circle the types of jobs you have held:

-Receptionist/ Administrative Assistant/ Clerical

-Library Assistant

-Dining Staff

-Computer Lab Assistant

-Research Assistant

-Other (please specify): ______________________

If you have previously held a job off campus, please circle the types of jobs you have held:

-Receptionist/ Administrative Assistant/ Clerical

-Library Assistant

-Dining/Restaurant Staff

-Computer Lab/Helpdesk Assistant

-Research Assistant

-Other (please specify): ______________________

APPENDIX B
TESTING PROTOCOL

Part 1

Please name the five positions that you found as a result of your search:

____

____

____

____

____

Please Record as many of the duties associated with each job you listed above that you can remember:

Job:

Duties:

Job:

Duties:

Job:

Duties:

Job:

Duties:

Job:

Duties:

Part 2: True/False

Please answer the True/False Statements Listed below.

If a Statement is True, please circle T. If a Statement is False, please Circle F.

1. One of the positions I found involved liking to work with books.

   T F

2. One of the positions I found involved working with plants.

   T F

3. One of the positions I found involved checking out music material.

   T F

4. One of the positions I found involved cleaning floors.

   T F

5. One of the positions I found involved organizing things.

   T F

6. One of the positions I found involved repairing computers.

   T F

7. One of the positions I found involved explaining computer programs to students.

   T F

8. One of the positions I found involved preparing test tubes.

   T F

9. One of the positions I found involved chopping vegetables.

   T F

10. One of the positions I found involved handling money.

T F

11. One of the positions I found was a Biology Research Assistant.

T F

12. One of the positions I found was a Library Supervisor.

T F

13. One of the positions I found was a Stack Assistant.

T F

14. One of the positions I found was a File Assistant.

T F

15. One of the positions I found was a Cashier.

T F

16. One of the positions I found was a Technical Course Instructor.

T F

17. One of the positions I found was a Clerical Assistant.

T F

18. One of the positions I found was a Prep Cook.

T F

19. One of the positions I found was a Chemistry Research Assistant.

T F

20. One of the positions I found was a Computer Lab Assistant.

T F

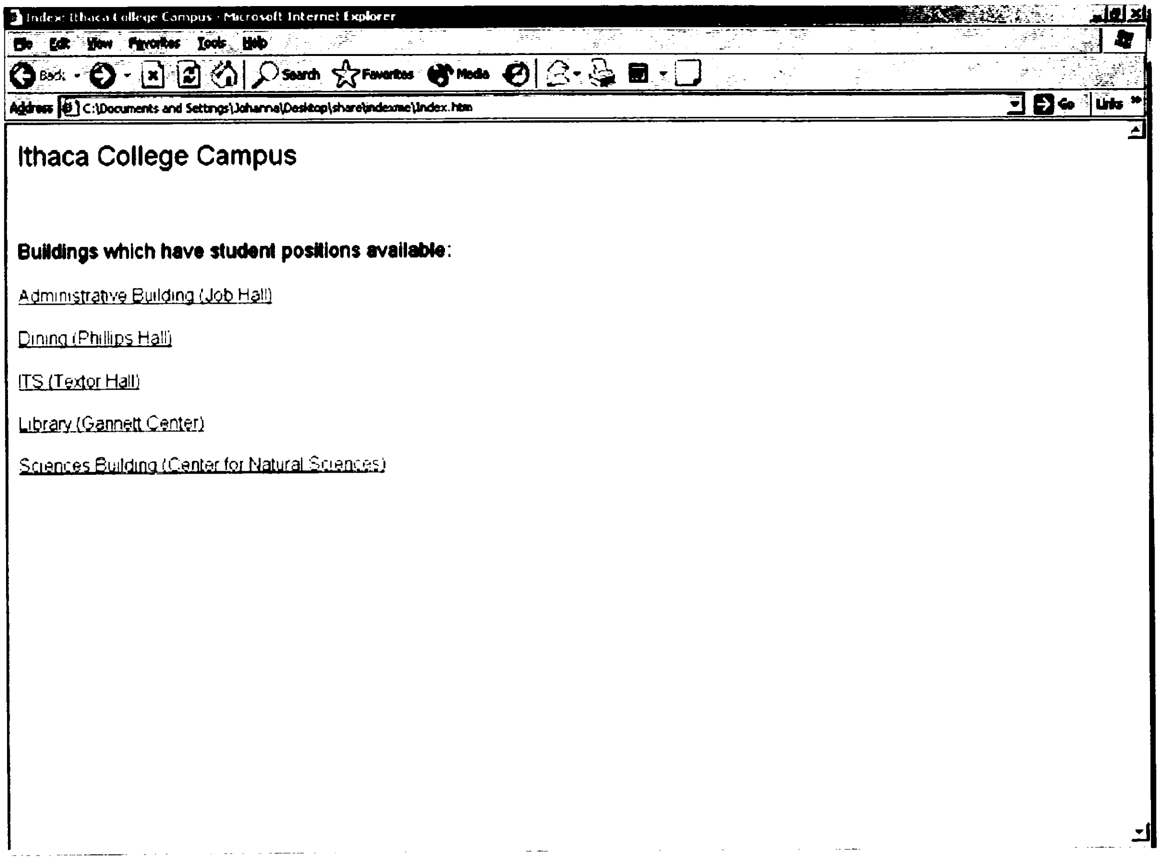
APPENDIX C

OPEN-ENDED INTERVIEW PROTOCOL AND SAMPLE QUESTIONS

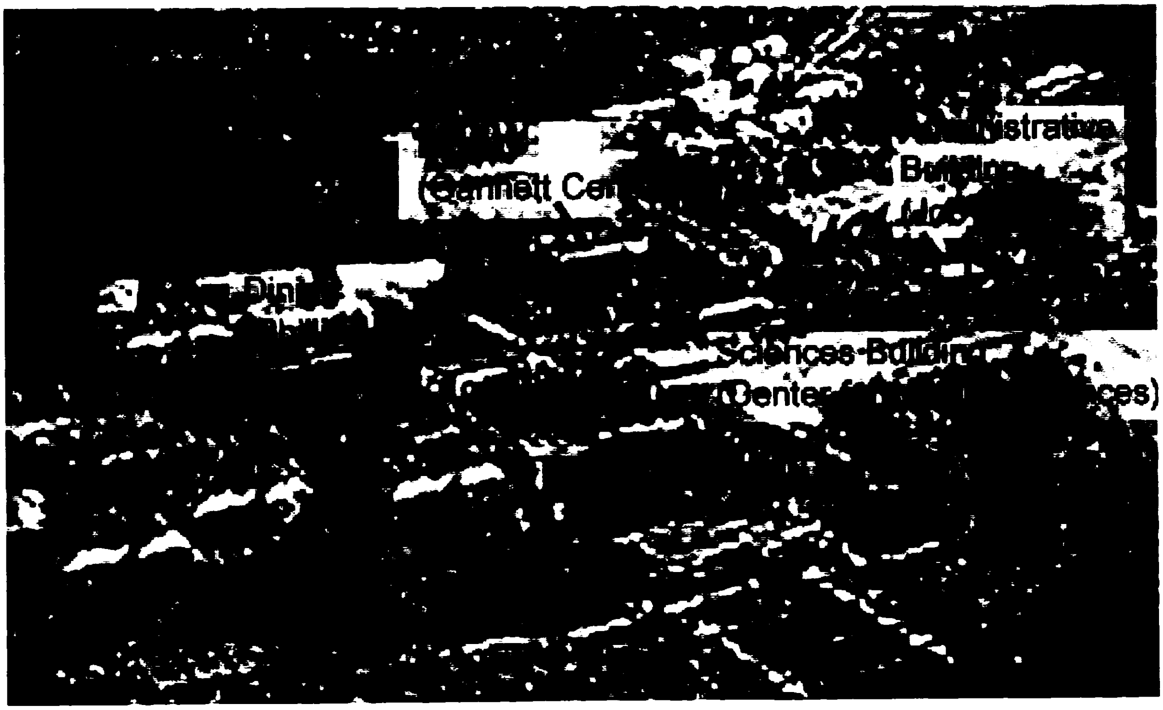
At the start of the interview, the researcher will explain that the interview seeks to understand what the subject thought and how he or she dealt with the user interface. The researcher will remind the subject that they do not have to answer any of the questions posed and that they can discontinue participating in the interview at any time if they wish to do so. The subject will also be reminded that the interview will be audio taped.

Questions:
Did you encounter any problems with using the system?
What were the problems that you encountered while using the system?
How did you cope with these problems?
What did you think worked well in the interface you used today?
What are your suggestions for its improvement?
How did you feel about using this interface?
How did using this interface compare to other web pages you have used?
How easy was this interface to navigate?
Did you notice that the interface was designed around a metaphor? A metaphor is an implicit (or implied) comparison between two objects for the purpose of brief explanation. For example, a familiar metaphor may be "All the world is a stage."
If you were searching for a job on campus, would you like to use this interface to find a job? Why or why not?

APPENDIX D.1
NON-SPATIAL METAPHOR: AN INDEX



APPENDIX D.2
SPATIAL METAPHOR: THE ITHACA COLLEGE CAMPUS



APPENDIX E
PARTICIPANT DEMOGRAPHIC INFORMATION

Age, Sex, and Class Year

The average age, as well as the sex and class year indicated by the participants on the user characteristic survey can be seen in *Table A1*.

Table A1

Age, Sex, and Class Year of Participants

Condition	Average Age	Sex		Class Year		
		Male	Female	Freshman	Sophomore	Junior
Non-spatial Metaphor	18.67	6	9	9	9	0
Spatial Metaphor	19.00	6	9	8	6	1
Total	18.83	14	16	14	15	1

Nationality

The nationality that participants indicated within each condition, as well as for the total experiment can be seen in Table A2.

Table A2

Nationality of Participants

Condition	Nationality				
	United States (American)	Chinese	Columbian	Serbian	Declined to Answer
Non-Spatial Metaphor	13	1	0	0	1
Spatial Metaphor	12	0	1	1	1
Total	25	1	1	1	2

Work Experience

The majority of participants indicated that they had not held an on campus job (Table A3). For those participants who held on-campus jobs, the type of position they held is specified. The majority of participants indicated that they had previously held an off-campus position (Table A4). Many of these participants indicated that they had held more than one type of off-campus position. As a result of this, many participants are counted more than once in the table.

Table A3

Participants' On-Campus Work Experience (by position type)

Condition	Have Not Held a Campus Position	Have Held a Campus Position, by type			
		Dining	Clerical	Teaching Assistant	Residential Advisor
Non-Spatial Metaphor	8	6*	1†	2*†	0
Spatial Metaphor	9	5**	1	0	1**
Total	17	11	2	2	1

Notes:

*One of these participants indicated that she had held positions in dining and had also served as a teaching assistant, and therefore is counted twice in the table.

† One of these participants indicated that she had held a clerical position and had also served as a teaching assistant, and therefore is counted twice in the table.

** One participant indicated he had held positions both in dining and as a Residential Advisor, and therefore is counted twice in the table.

Table A4

Participants Off-campus Work Experience (by Type)

Condition	Have Not Held a Off-Campus Position	Have Held an Off-Campus Position, by type					
		Retail	Dining	Outdoor/ Physical Education*	Industrial**	Manual Labor†	Media Positions††
Non-Spatial Metaphor	2	5	4	5	3	0	0
Spatial Metaphor	1	5	4	4	2	2	2
Total	3	10	8	9	5	2	2

* Positions such as swimming and skiing instructors, lifeguards, and camp counselors

** Positions such as assembly line work

† Positions such as deckhands and gardeners

†† Positions such as photographers and video-grapher

Application Use

All of the participants indicated that they used Email, Word Processing, and the Internet. Participants reported a variety of application use (Table A5).

Table A5

Number of Participants Who Reported Use of Certain Applications

Condition	Application									
	Email	Word Processing	Internet	Graphic Software	Spreadsheet Software	Instant Messenger	Html Editor	Finale Notepad	iTunes	Final Cut Pro
Non-Spatial Metaphor	15	15	15	9	4	1	1	1	0	0
Spatial Metaphor	15	15	15	1	4	2	0	0	2	1
Total	30	30	30	10	8	3	1	1	2	1