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ABSTRACT

This study investigated the relationships between hypermedia users' information processing styles and navigational patterns. Three aspects of navigational patterns were investigated: navigational depth patterns that reveal how comprehensively users access; navigational path patterns that display what sequences users follow; and navigational method patterns that show what methods users employ when using the system. Subjects were 102 undergraduate students enrolled in management courses. Information processing styles were measured by the Human Information Processing Survey. Thirty-four students were selected for each of left, right, and integrated information processing style groups. The subjects interacted with the A.g.i.l.e. Resource(TM) trainer program to complete open-ended and closed-ended tasks. Significant differences were found among groups in navigational depth patterns; right dominant information processing style subjects accessed significantly more new nodes than left dominant subjects. There was a significant relationship between information processing style and navigational path patterns; right dominant subjects followed significantly more linear paths than integrated subjects. There was a significant relationship between information processing styles and navigational method patterns; left dominant subjects employed significantly more analytical methods than right dominant subjects, and integrated subjects used significantly more analytical methods than right dominant subjects. Results indicate that information processing style plays an important role in how an individual interacts with hypermedia systems. (Contains 77 references.) (Author/MES)

THE RELATIONSHIPS BETWEEN NAVIGATIONAL PATTERNS AND INFORMATIONAL PROCESSING STYLES OF HYPERMEDIA USERS

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Abstract

This study investigated the relationships between hypermedia users' information processing styles and navigational patterns. Three aspects of navigational patterns were investigated: (a) navigational depth patterns which reveal how comprehensively users access, (b) navigational path patterns which display what sequences users follow, and (c) navigational method patterns which show what methods users employ when using the system.

Information processing styles were measured by the Human Information Processing Survey. The subjects were 102 undergraduate students enrolled in management courses at a university. Participation was voluntary. 34 students were selected for each of left, right, and integrated information processor group. The subjects interacted with A.g.i.l.e. Resource™ program to complete two types of searching tasks, open-ended and closed-ended tasks.

Findings indicated that:

1. Significant differences were found among groups in navigational depth patterns. The right dominant information processing style subjects accessed significantly more new nodes than did the left dominant information processing style subjects.

2. There was a significant relationship between information processing style and navigational path pattern. The right dominant information processing subjects followed significantly more linear paths than the integrated information processing style subjects. The right dominant information processing subjects also followed a lot more linear paths than the left information processing style subjects, although it was not statistically significant.

3. There was a significant relationship between information processing styles and navigational method patterns. The left dominant information processing style subjects employed significantly more analytical methods than the right dominant information processing style subjects. In addition, the integrated information processing style subjects used significantly more analytical methods than did the right dominant information processing style subjects.

The present study demonstrated that the information processing style seems to play an important role in how an individual interacts with the hypermedia systems. The conclusion should be confirmed by additional research.

Introduction

Statement of the Problem

Hypermedia systems, used as sophisticated databases and instructional delivery systems, are becoming more powerful and hence more popular in educational and corporate environments. A review of the literature on hypermedia systems indicates that these rapidly evolving systems offer two unique features over traditional media: (a) increased richness of information and (b) nonlinearity of information structure. Many researchers claimed that the overall advantage of hypermedia systems with these two unique features is the ability to accommodate individual differences in various users' learning styles so that learning can be more effective for everyone (Ayersman, 1993; Bermudez & Palumbo, 1994; Grice & Ridgway, 1995; Jonassen, 1988; Larson, 1992). Current interest in hypermedia systems, however, has focused mainly on the systems implementation and software development. Little attention has been paid to the complexity of how different learning style users actually interact with non-linear hypermedia systems (Ayersman, 1996; Beasley & Waugh, 1997; Harmon & Dinsmore, 1994; Savenye, Leader, Jones, Dwyer, & Jiang, 1996).

Many research studies, on the other hand, have focused exclusively on analysis of general users' navigational patterns and categorizing navigational patterns in hypermedia systems themselves. These studies indicate that there are considerable variation among different users in their navigational patterns, including navigational depth which reveals how comprehensively users access the system, navigational path which displays what sequences users travel, and navigational method which shows what navigational means users employ when using the system (Barab, et al., 1997; Beasley & Vila, 1992; Canter et al., 1985; Horney, 1993; Orey & Nelson, 1994; Savenye, 1996; Qiu, 1993). However, relatively few studies have investigated further to identify the factors that might impact diversity of navigational patterns among different users.

The information processing styles implies great influence on variation of individuals' navigational behaviors. The findings of separate bodies of research in information processing styles and navigational patterns imply that left-right brain dominant information processors might interact quite differently within nonlinear hypermedia systems applying different navigational strategies. Unfortunately, there has been little research to bring the possible implications of information processing styles on users' interaction related to hypermedia systems.

Purpose of the Study

The purpose of this study was to investigate the relationships between users' information processing styles and navigational patterns within hypermedia systems. This study investigated individuals' information processing styles and examined whether information processing styles is related to users' navigational patterns in hypermedia systems. Three aspects of navigational patterns were investigated: (a) navigational depth patterns which reveal how comprehensively users access, (b) navigational path patterns which display what sequences users follow, and (c) navigational method patterns which show what methods users employ when using the system.

Theoretical Framework

Nonlinearity of Hypermedia Systems

Traditional computer-based instruction (CBI) systems are rigid in their information structure (Ellis et al., 1993). The learner has to follow a limited number of predetermined paths, which are structured usually in a linear fashion. Therefore, little opportunity exists for individual choices and hence everybody has to use the system in much the same way.

In comparison, hypermedia systems eliminate the constraints of sequential presentation of information. Instead of organizing and presenting information sequentially with traditional books and CBI systems, hypermedia systems adapt a different concept of information structure. Information in a hypermedia system is stored as small discrete units and is linked together into complex networks. Unlike traditional information systems, which have mostly linear structure, hypermedia systems are nonlinear.

In general, nonlinear hypermedia systems provide users much greater control over navigational strategies than any other traditional media. Nonlinear hypermedia systems allow users to use personalized information-seeking strategies and hence users of hypermedia systems can make their own decisions about navigational strategies based on individuals' preferences to accomplish their objectives and/or needs. In this context, researchers claimed that hypermedia has great potential to address individual differences in users' learning styles (Ayersman, 1993; Rabbitt & Miller, 1996; Jonassen, 1988; Knussen, Kibby, & Tanner, 1991; Reed & Oughton, 1997). The researchers believed that individuals will actively interact with the systems, exploiting the navigational advantage of the nonlinear structure according to users' preference for learning styles. This belief requires further study.

Present State of Research on Navigational Patterns in Hypermedia Systems

According to Ayersman (1996) and Barab, Bowdish, and Lawless (1997), few studies have been conducted to investigate the nature of different individual users' navigation within hypermedia systems. Reed and Oughton (1997) and Savenye et al. (1996) also argued that little empirical research pertaining to how different users interact with nonlinear hypermedia applications has been conducted to date, and that more research needs to be done.

Meanwhile, many other research has focused more exclusively on categorizing navigational patterns in hypermedia systems themselves. The navigational patterns found in the literature are mainly divided into three categories: (a) navigational depth patterns which reveal how comprehensively users access the system, (b) navigational path patterns which display what sequences users follow, and (c) navigational method patterns which show what methods users employ when using the system.

Researchers examined users' navigational depths accessed within hypermedia systems (Canter, Rivers, & Storrs, 1985; Schroeder and Grabowski, 1995). Canter et al. examined navigational depths as an indication of the range of exploration undertaken by users. They grouped navigational depth patterns into three different ranges as high, medium, and low exploration.

Other studies examined users' general navigational path patterns in hypermedia systems. Orey and Nelson (1994) identified four categories of navigational path patterns: *rings, loops, paths, and spikes*. Similarly, Horney (1993) described five navigational path patterns including *linear traversal, side trip, star, extended star, and chaotic*. Although these researchers identified various and specific navigational path patterns with hypermedia systems, other researchers categorized navigational path patterns in hypermedia systems more generally, as linear and nonlinear path patterns (Beasley & Vila, 1992; McCluskey, 1993; Parunak, 1989).

Researchers also examined prominent navigational methods users employed when using the system (Beasley & Vila, 1992; Dias & Sousa, 1997; Nielson, 1989; Qiu, 1991, 1993; Savenye et al, 1996). Navigational methods commonly included in hypermedia systems consist of index, keywords search functions, maps, hypertexts, menus, and tables of contents. These navigational method patterns were categorized into two groups, analytical and holistic methods, based on the property of the navigational methods (Campagnoni & Ehrilch, 1989; Marchionini & Shneiderman, 1988; Qiu, 1993). According to Marchionini and Shneiderman (1988), analytical methods are direct navigational means which involve a well-structured search for specific information, while holistic methods are more likely indirect means which involve a relatively unstructured search and assist users' searching process indirectly.

The overall conclusion of those studies on navigational patterns is that there is a great deal of diversity in navigational patterns which individuals employ, including navigational depth, path, and method patterns. In addition, it is widely accepted that the diversity of navigational patterns results from individuals' travel within hypermedia systems using different navigational strategies. Most of the studies, however, did not investigate further why different users rely on so many different navigational strategies when utilizing hypermedia systems. Furthermore, few of these studies considered individuals' learning styles that might impact on users' navigational strategies.

Learning Styles and Information Processing Styles

The term "learning styles "has been used interchangeably with "cognitive styles," "brain dominance," "information processing styles," and "learning modalities" by many (Ayersman, 1993 & 1996; Entwistle, 1981; Liu & Reed, 1994; Marrison & Frick, 1994; Shaughnessy, 1996).

Learning style has long been considered a fundamental element in individual differences, which impact on problem solving strategies in various learning situations (Ayersman, 1993; Carbo, Dunn, & Dunn, 1986; Hanson, 1996; Leader & Klein, 1996; Wilson, 1988). Numerous models for learning styles have been developed. The models are slightly different based on which cognitive variables each model stresses in the learning process.

Witkin's Cognitive Styles (Witkin, 1950) focuses on how learners perceive information in terms of learners' dependency and independency on a surrounding learning environment. Kolb's Learning Styles (Kolb, 1985) deals more with learners' general attitudes in the learning process, such as converger, diverger, assimilator, and accommodator. Sensory Modalities (Sprinthall & Sprinthall, 1990) focuses on individual preferences for sensory input of information as visual learners and auditory learners. Brain hemisphericity (Sonnier, 1992, 96) deals with specific problem solving strategies in performing cognitive tasks based on hemispheric processing preference style.

The information processing styles based on brain hemisphericity theory focuses particularly on individuals' differences in overall information processing strategies for problem solving based on hemispheric information processing preference (Gardner, 1985; Hunter, 1976; Sonnier, 1992; Torrance, 1982; Torrance & Taggart, 1984). The information processing style model examines closely the cognitive strategies of how individuals approach problem solving differently in various learning situations. In this context, information processing style model suggests greater implications on users' navigational strategies than any other learning style models described, since navigational patterns are representations of the strategies used by individuals to process information in nonlinear hypermedia systems.

Functional lateralization of the brain has been investigated in efforts to explain the differences in the abilities of the two halves of the brain. There has been much evidence indicating that there are areas of specialization giving each hemisphere dominance in controlling particular cognitive functions. The overall indications in related literature are that the left hemisphere is predominantly involved with analytic thinking, specifically, language and logic. The right hemisphere, one the other hand, is involved primarily with holistic thinking, responsible for orientation in space, artistic talents, and bodily awareness (Gardner, 1985; Hellige, 1993; Iaccino, 1993; Springer & Deusch, 1989; Taggart & Torrance, 1984).

In addition, human beings are thought to vary in terms of their cerebral dominance. The notion of hemispheric dominance among people is that the individual has an overall preference for using cognitive ability of one side of the brain for problem solving. Numerous studies support the notion of preferred style in hemispheric processing preference among individuals (Herrmann, 1981; Shaughnessy, 1996; Torrance et al., 1984; Zaidel, Clarke, & Suyenobu, 1990). These studies suggest that left-dominant processors usually prefer structured tasks, approach tasks systematically, use analytical strategies, solve problems logically, and are more likely to process information in linear fashion. In contrast, right-dominant processors tend to prefer open-ended tasks, approach tasks by exploration, use holistic strategies, solve problems intuitively, and process information in nonlinear ways.

Implications of Information Processing Styles on Users' Navigation Patterns

Findings of research in brain hemisphericity theory suggest that each side of the brain is dominant in controlling particular cognitive functions for problem solving and that human beings vary in terms of their cerebral dominance. Many studies investigated the effects of individuals' cerebral dominance on problem solving strategies and these studies indicated that cerebral dominance impacts problem solving strategies among people in various learning environments (Herrmann, 1981; Hough, 1987; Robey & Taggart, 1982; Shaughnessy, 1996; Zaidel et al., 1990).

Information processing styles categorized according to brain hemisphericity theory might impact on users' navigational patterns within hypermedia systems. That is because navigational patterns are representations of the strategies used by individuals to process information in nonlinear hypermedia systems much the same as with individuals' problem solving strategies in various other learning environments. Then, there might be relationships between information processing styles among people and navigational strategies they employ within hypermedia systems.

On the basis of the findings of research in information processing styles and navigational patterns, it is implied that left brain dominant information processors might prefer to explore hypermedia systems in a relatively limited depth while right brain dominant information processors might tend to explore with hypermedia systems in a relatively comprehensive depth pattern. Left brain dominant information processors might prefer to access nodes in much more linear path patterns while right brain dominant information processors might be inclined to interact with hypermedia systems in relatively nonlinear path patterns. Similarly, left brain dominant information processors might prefer to navigate within hypermedia systems using more analytical navigational methods such as using index and keyword functions. In contrast, right brain dominant information processors might travel hypermedia systems using more holistic navigational features such as map, hypertext, and table of contents.

Research Questions

The general research questions of this study were as follows:

1. What are the relationships between hypermedia users' information processing styles and their navigational depth patterns?
2. What are the relationships between hypermedia users' information processing styles and their navigational path patterns?
3. What are the relationships between hypermedia users' information processing styles and their navigational method patterns?

Significance of the Study

Results of the study would provide insights into the relationships between navigational patterns and information processing styles of hypermedia users. These results then would provide useful information for advising learners regarding selecting more efficient and effective navigational patterns based on their information processing styles. In addition, the detailed information of users' navigational behaviors could provide further guidance for designing hypermedia applications that are more effective and more user-centered. The results of this study could also provide additional information that would verify the effectiveness of hypermedia systems in terms of addressing individual differences.

Method

Operational Definitions

Hypermedia Environment: The A.g.i.l.e. Trainer™ hypermedia program developed by Knowledge Solutions Inc. Bethlehem, PA (Harvey & Nelson, 1995).

The A.g.i.l.e. Trainer™ includes a more flexible navigational structure that uses pull-down menus than other programs in which "next" and "previous" buttons are the most obvious navigational means to travel the system. Refer to Figure 1 through Figure 3 for basic screen layouts of three sets of pull-down menus in the A.g.i.l.e. Trainer™.

It is important to note that lists of resources in the pull-down menus represent the available nodes in the experimental system. The researcher used the term node when referring to an information resource in the system.

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Figure 1. Pull-Down Menu in "Course" Interface

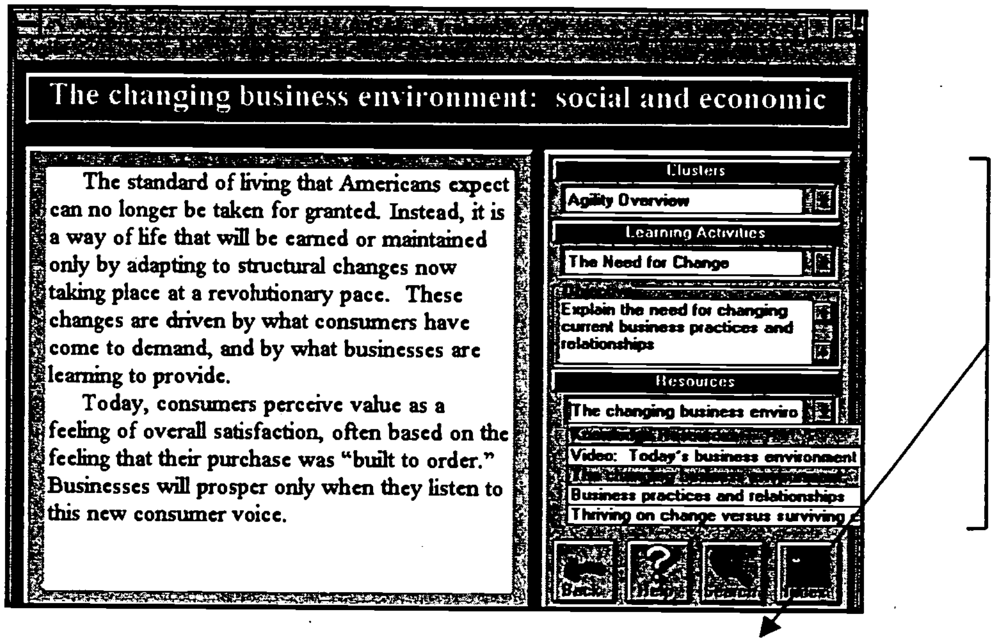


Figure 2. Pull-Down Menu in "Search" Interface

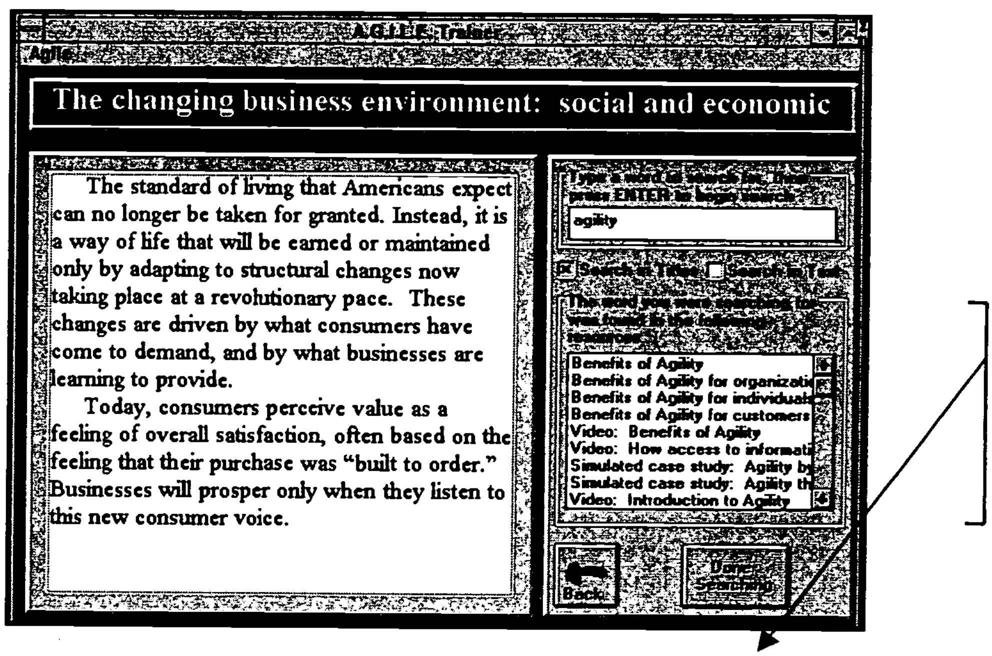
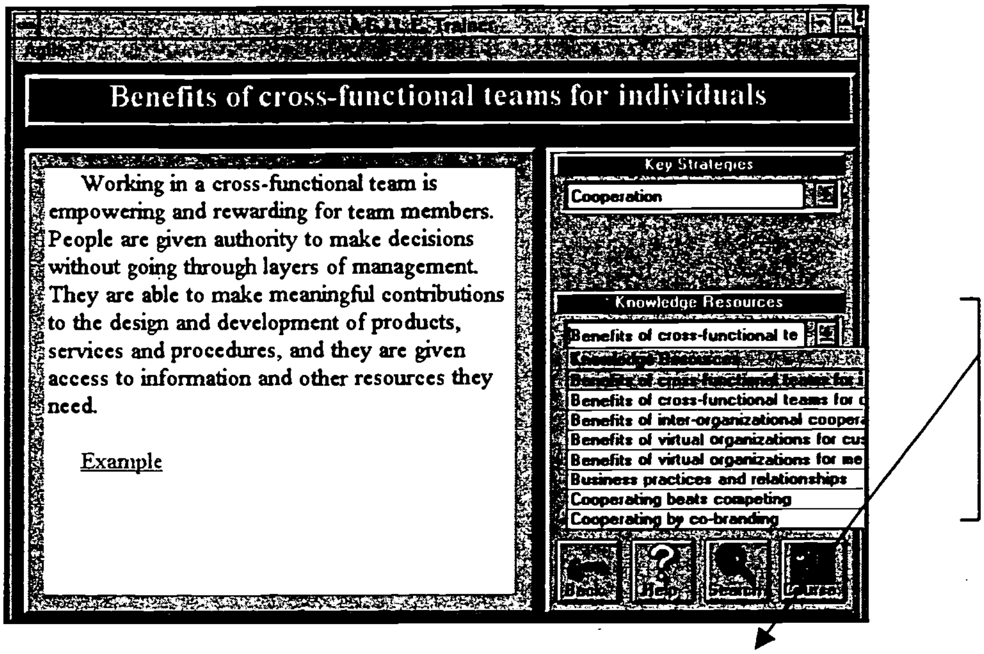


Figure 3. Pull-Down Menu in "Index" Interface



Left, Right, and Integrated Information Processors:

Three different styles of information processors categorized by the Human Information Processing Survey (HIPS) (Torrance et al., 1984).

It should be noted that the HIPS categorizes four different information processors: (a) left, (b) right, (c) integrated, and (d) mixed. The mixed information processors, however, was excluded from this study. The reason for excluding this group was that mixed information processors typically use either left or right brain dominant strategies at random and therefore this group of people was not likely to show any dominant navigational patterns.

Navigational Depth

Subjects' scores on exploration value, which is adapted from Canter et al. (1985):

$$\text{Exploration value} = \frac{\text{The number of different nodes visited}}{\text{The total number of nodes available in the system}}$$

The exploration value ranges from 0 to 1. The higher the exploration value, the more comprehensive the navigational depth pattern is and the lower the exploration value, the more limited the navigational depth pattern is in the current study.

Depth refers to the degree of users' exploration by accessing nodes both in different levels and across the same level in the system structure. It should be noted that nodes visited repeatedly are counted only once in the current study. That is because the objective here is to examine how comprehensively users explore various nodes available in the system. The performance of subjects who take repeated visits to the same node will be analyzed in a follow-up study.

Navigational Path

Subjects' scores on linearity value, which is defined as:

$$\text{Linearity value} = \frac{\text{The number of linear navigational links followed}}{\text{Total number of either linear or nonlinear navigational links followed}}$$

A linear link is defined as a link between two nodes connecting a node to a subsequent node that is listed adjacent to the first node chosen in a pull-down menu. A navigational link between two nodes connecting a node to the previous node visited using "Back" button is also a linear link. A nonlinear link is defined as a link between two nodes connecting a node to a subsequent node that is not listed adjacent to the first node chosen in a pull-down menu. In addition, a link between two nodes connecting a node in a navigational method to a subsequent node in another method is a nonlinear link. Any navigational links connecting two nodes by clicking hypertexts were also considered as nonlinear links.

The linearity value ranges from 0 to 1. The higher the linearity value, the more linear the navigational path pattern is and the lower the linearity value, the more nonlinear the navigational path pattern is in the current study.

The pull-down menus display the list of nodes available in the system and users can access any information in the list at any time in any sequence. Users can navigate the system in either a linear or nonlinear sequence simply by choosing nodes which are listed adjacent to each other or which are not listed adjacent to each other, respectively, as indicated in the pull-down menus.

Navigational Method

Subjects' scores on analytical methods value, which is adapted from Qiu (1993):

$$\text{Analytical methods value} = \frac{\text{The number of analytical methods employed}}{\text{Total number of navigational methods employed by analytical, holistic, or mixed methods.}}$$

Analytical methods are defined as navigational means that lead a direct and well-structured search for a specific information sought. Analytical methods include search (keyword search) and index. Holistic methods are defined as indirect and less-structured navigational means that assist users indirectly to find information sought. Holistic methods include course (table of contents), help, back, done searching, and hypertext.

An analytical or a holistic method were counted each time one of the method is used to create a link between two nodes. A mixed method was counted each time combinations of analytical and holistic methods are used to create a link between two nodes.

Analytical methods value ranges from 0 to 1. The higher the analytical methods value, the more analytical the navigational method pattern is and the lower the analytical methods value, the more holistic the navigational method pattern is in the current study.

The A.g.i.l.e. Trainer ™ program supports the following navigational methods summarized in Table 1.

Table 1. Types of Navigational Methods in A.g.i.l.e. Trainer™ Program

Methods	Description	Analytical-Holistic
Back	To return to the node user most recently visited.	Holistic
Course	To bring an interface which allows user to search information using a pull-down menu.	Holistic
Search	To bring an interface which allows user to search specific information by typing keywords.	Analytical
Done Searching	To return to the course interface from search interface.	Holistic
Help	To go to a help screen about general guidelines for navigating the system.	Holistic
Index	To bring an interface that allows user to search specific information presented in index.	Analytical
Hypertext	To go another node which describes the content about the hypertext by jumping to a node out of sequence in the system.	Holistic

Sample

The sample subjects were 102 undergraduate students enrolled in management courses in the College of Business and Economics at Lehigh University. Participation was voluntary. To ensure maximum participation, incentives in the form of bonus points were offered in the courses in which the subjects were enrolled. Thirty four students were selected for each type of hemispheric processing preference style (left, right, or integrated).

Instruments

Human Information Processing Survey

Human Information Processing Survey (HIPS) is a tool for assessing individuals in terms of hemispheric processing preference (Taggart & Torrance, 1984). This survey yields four possible categories of information processors: (a) left dominant, (b) right dominant, (c) mixed, and (d) integrated information processors. According to Taggart and Torrance, left brain dominant processors think in predominantly systematic ways, approach tasks sequentially, and solve problems analytically. On the other hand, right brain dominant processors are believed to adapt primarily the opposite strategies in problem solving such that they think in an exploratory manner, approach tasks non-sequentially, and solve problems in holistic ways. Integrated information processors are individuals who use simultaneously the left and right dominant strategies in proportion appropriate for the situation while mixed information processors are individuals who use either a left dominant or a right dominant strategy at random.

Open-Ended Questions and Closed-Ended Questions

The researcher designed two types of computer task questions, 3 items for open-ended tasks and 5 items for closed-ended tasks in order to assist users in using the experiment program purposely and comprehensively. Open-ended tasks in this research required users to respond in general terms based on understanding the overall content of the hypermedia system. Close-ended tasks in this research required users to respond in specific terms that can be found in the hypermedia system.

The questions were reviewed by the developer of the A.g.i.l.e Resource ™ hypermedia program, Dr. Nelson, Vice President for Development, Knowledge Solution Inc. to determine whether questions adequately address the intention for leading users to use the program purposely and comprehensively. He agreed that the questions adequately address the purpose. It was not necessary to make any changes to the instrument. No formal statistical analysis to determine reliability of the instrument was performed since the questions are a part of treatment to assist the subjects in using the experiment program purposely.

Subject Demographic Information Questionnaire

The researcher designed a subject demographic information questionnaire. The questionnaire was used to collect demographic data on the sample in order to determine gender, age, year in college, previous computer training, and computer expertise of each subject.

Demographic data were used to determine whether there were initial differences other than brain hemisphericity among three information processor groups. No formal statistical analysis to determine validity and reliability of the instrument was performed since the questionnaire was not for testing any effects. Rather, the questionnaire was for collecting demographic information of the subjects.

Research Design

The causal-comparative research design was used to explore the relationships between hypermedia users' information processing styles and their navigational patterns. The causal-comparative research method was selected instead of the experimental method because it allows the researcher to study the relationships between variables under a condition where experimental manipulation is not possible. It was impossible for the researcher to manipulate hypermedia users' information processing styles and their navigational behaviors in using the program. The hypermedia program were also given as a study environment rather than as an experimental treatment manipulated for the study.

The independent variable in the present study was the informational processing styles of the users. It had three categories: (a) left dominant information processors, (2) right dominant information processors, and (c) integrated information processors. The dependent variables were the three different navigational patterns: (a) navigational depth patterns, (b) navigational path patterns, and (c) navigational method patterns.

Three separate one-way analysis of variance (ANOVA) were used to test the three hypotheses stated individually. ANOVA was selected to test the null hypotheses because the study involves comparison of three groups. The researcher also judged that three separate one-way ANOVA would be appropriate to test the hypotheses since the study had one categorical independent variable and three measured dependent variables which were not related to one another (Borg & Gall, 1989).

The Statistical Package for Social Science (SPSS Inc., 1995) was used to perform the ANOVA procedures. An alpha level of .05 was set as the criterion for rejection of the null hypothesis. According to Borg and Gall (1989), the .05 level is the most commonly chosen alpha level for rejecting the null hypothesis in educational research.

A power level of .70 assuming a medium effect size of .25 was used throughout the study. Cohen (1969) reported that .80 serves as a convention for desired power level.

Pilot Study

A pilot study was conducted to make sure that the procedures and the instruments to be used in the study operate properly. The main objective of the pilot study was to test the hypermedia system and computer utility that records users' interactions within the hypermedia system. At the conclusion of the pilot study, procedures and instruments were examined by the researcher to determine if they performed satisfactorily. Some minor changes were made according to the results of the pilot study.

Research Study

Hypermedia Program - A.g.i.l.e. Trainer™

The A.g.i.l.e. Trainer™ is an interactive multimedia CD-ROM knowledge base about organizational agility and examples of agile practices. The A.g.i.l.e. Trainer™ is developed by Knowledge Solutions Inc., Bethlehem, PA (Harvey & Nelson, 1995). The program is designed as a reference tool or self-teaching module. It is aimed toward various levels of users in terms of computer experience from novice computer users to expert computer users.

The A.g.i.l.e. Trainer ™ contains various types of information including text, graphics, sound, video, and animated segments that illustrate principles and provide examples about agility. The A.g.i.l.e. Trainer ™ provides hundreds of resources about agility and introduces more than 175 companies as examples of high-performance in business. The A.g.i.l.e. Trainer ™ has powerful features that are easy to use. Hundreds of information-providing text screens are electronically linked and the relationships among them are apparent.

The A.g.i.l.e. Trainer™ requires a 386 or higher IBM compatible computer, 256 color VGA monitor, MPC compatible sound card and speakers, at least 4MB RAM, 5MB HD space, and Windows 3.1 or later.

Search Tasks

Previous studies indicated that the search task is a major factor that influences navigational patterns in general (Campagnoni & Ehrlich, 1989; Nielson, 1989; Qiu, 1993). For instance, an open-ended task leads users to navigate the hypermedia system using holistic methods while a closed-ended task leads users to employ more analytical methods. The current research, however, attempted to determine the relationship between users' information processing styles and navigational patterns within hypermedia system regardless of search tasks. The researcher, therefore, provided two types of tasks, open-ended tasks and closed-ended tasks for all users, so that users would navigate the hypermedia program for identical tasks.

Procedures

The research study administered by the researcher and an assistant throughout most of data collection process. The assistant trained to help the research process only as directed by the researcher in order to avoid any risk of having the results affected by the assistant. The assistant was not allowed to respond to any requests or questions directly related to the research study. Rather, the assistant helped only for mechanical tasks such as distributing materials, collecting materials, installing the A.g.i.l.e. Trainer™ program, trouble shooting, and other activities that would not affect the results.

The research study was divided into two sessions, session A and session B. Session A was for drawing sample subjects and session B was for conducting the main experiment with the hypermedia program.

In session A the researcher visited three management classes, MGT 269(1), MGT269 (2), and MGT 270, in the College of Business and Economics. The combined enrollment of these classes was approximately 200 students with about 65 students for each class. Professors of each class, Dr. Trent and Dr. Poole, agreed to have their students participate in the study and to offer incentives in the form of extra credit in the courses that the subjects were enrolled. The researcher visited the three management classes at the end of each class. Each student was given a brief explanation of what was required of him or her in the experiment and a consent form was signed. The subjects were then be asked to complete the Human Information Processing Survey (HIPS) which is a pencil and paper self-report inventory. The survey took 20 to 30 minutes.

Upon completion of the HIPS, the researcher scored the responses and identified subjects' hemispheric processing styles following the instructions in the HIPS. the researcher selected randomly among the participants approximately 40 subjects, using a lottery system for each type of hemispheric processing preference style (left, right, or integrated) for the experiment. The selected subjects then were asked to choose a time slot on the schedule arranged for the main experiment. Experiment times were scheduled at least twice a day for five days, one AM and one PM, for an hour so that subjects could participate at times that were convenient for them.

In session B subjects were assigned identification numbers randomly by following a lottery system. These assigned numbers were used on all tests and forms to be completed by the subjects. The master list of assigned numbers were maintained by the researcher.

Subject demographic information questionnaires were administered to all subjects before they participated the main experiment with the hypermedia program. The directions for how to use the hypermedia system and the main experimental procedure were given using a videotape recording in order to keep the consistency among subjects who participated in the experiment at different experiment times. Prior to conducting the formal experiment with the program the videotape provided a short demonstration to the subjects about the experimental system including the overall structure of the hypermedia system and how to navigate within the system. All subjects had an opportunity to try out the system until they feel confident about using it.

The subjects then were asked to perform the two tasks. The first task was to answer the open-ended questions based on the content in the hypermedia system. The subjects were asked to browse the hypermedia system, A.g.i.l.e. Trainer™, to get familiar with the concept of Agility and to answer the three general questions in the work sheet. A copy of the open-ended questions were given to the subject after subjects review the program as they might wish. The researcher was not be able to answer any questions the subjects might have while subjects interacted with the experimental program, other than making sure equipment was operating correctly. The users interaction activities with the hypermedia system were recorded using a Window environment utility called 'Recorder.' The Recorder recorded user interactions simultaneously while users interacted with the hypermedia system. The computer files of the recording results were saved by the researcher and the assistant when the subject indicated he or she was finished.

Next, the subjects were asked to perform the second task which were closed-ended questions to answer based on specific information that could be found in the hypermedia system. The researcher did not answer any questions the subjects might have while subjects interacted with the experimental program, other than making sure equipment was operating correctly. The users' interaction activities with the hypermedia system were again recorded using a Windows environment utility called 'Recorder.' The Recorder was running while users interacted with hypermedia system at the same time. The computer files of the recording results were saved by the researcher and the assistant when the subject indicated he or she was finished.

Data Collection

Details of each user's interactions with the hypermedia program were recorded using the 'Recorder' utility for Windows (Windows 3.1, 1993). The 'Recorder' automatically recorded and saved as a movie file exactly what users did and how they interacted with the program.

The measurement of the variables of the study required the development of a data processing procedure specifically for the study since the study uses a non-standard (self-developed) measure (Borg & Gall, 1989).

The researcher applied guidelines on data processing procedures from several research handbooks (Borg & Gall, 1989; Kidder, 81; Livingston, 1988; Savenye & Robinson, 1996) to develop valid and reliable data processing procedures. The data processing procedures in the study were as follows:

Data reduction procedures. The original data were collected using the 'Recorder' program. The 'Recorder' recorded exactly what users did and how users interacted with the experimental environment program saving the result as a recorder file just as the same format as a videotape recording. A data reduction process was needed to convert the original raw data from recorder files format to a written document format in order to simplify the process of representation and analysis of the data for the study (Kidder, 1981). One third-party reviewer reviewed the "Recorder" files and recorded subjects' interactions within the experimental program in a data reduction form in order to make the data ready for data coding process.

Data coding procedure. The researcher developed specific data coding rules for the study that included a set of specific steps to follow for data coding. An external evaluator reviewed the protocol of data coding rules in order to validate the rules for the study. The evaluator checked the coding rules to ensure clarity and the appropriateness of information so that raters could make decisions based on the coding rules.

The researcher refined the coding rules based on the evaluator's suggestions. When the final coding rules were ready, two external raters coded the data, following the coding rules. Two separate external raters coded the entire data set in order to yield more valid and more reliable results than would be produced by one rater alone. The coding rules were fully tested with the two raters before the raters actually applied the rules to code the data.

After coding trials indicated that the raters yielded satisfactory codes for the same data, each rater began to code separately the entire subjects' data. The researcher examined the results of the raters' coding data and resolved any disagreements in coding between the two coders.

Results

Descriptive Analysis

Demographic Data

The demographic data were obtained to determine whether there were initial differences other than information processing styles among three information processor groups. A demographic information questionnaire designed by the researcher was used to obtain complete descriptions of the subjects in three groups.

The researcher found strong similarities in the distribution of subjects among three groups in gender, age, years in college, previous computer training, and computer expertise. This demonstrates the benefits of drawing subjects from a large population group. The researcher used formal tests to verify that the groups were equivalent and represented the data in a later section of analysis of demographic data.

Analysis of Navigational Pattern

Navigational depth. Navigational depth is a measure reflecting how many new nodes a user visits when navigating in a hypermedia system. In this study, navigational depth was measured by the subjects' scores on exploration value, which was defined as the ratio of the number of different nodes visited to the total number of nodes available in the system. The exploration value will range from 0 to 1.

Table 2. Means and Standard Deviations for Navigational Depth

Groups	n	M	SD	S. Error
Left Information Processors	34	.0489	.0125	.0021
Right Information Processors	34	.0581	.0184	.0032
Integrated Information Processors	34	.0493	.0133	.0023

Navigational path. Navigational path is a measure reflecting which sequences a user travels when navigating in a hypermedia system. Navigational path was measured by subjects' scores on linearity value, which was defined as the ratio of the number of number of linear navigational paths followed to the total number of either linear or non-linear navigational paths followed. The linearity value ranges from 0 to 1.

Table 3. Means and Standard Deviations for Navigational Path

Groups	n	M	SD	S. Error
Left Information Processors	34	.3528	.1301	.0223
Right Information Processors	34	.4076	.1244	.0213
Integrated Information Processors	34	.3325	.0722	.0124

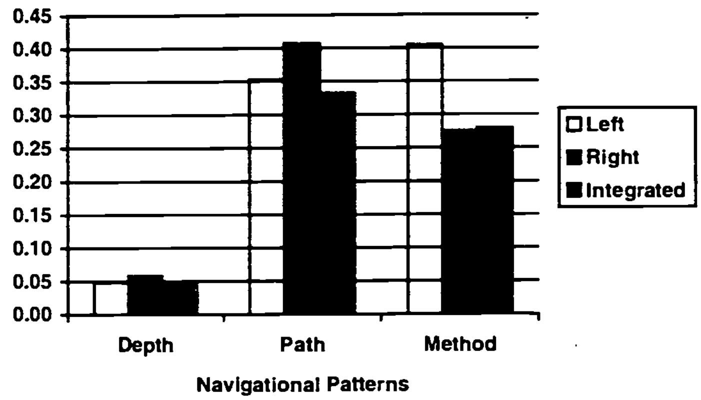
Navigational method. Navigational method is a measure reflecting which methods users employ when navigating in a hypermedia system. The score was measured by the analytical methods value, which was defined as the ratio of the number of analytical methods employed to the total number of either analytical or holistic navigational methods employed. Analytical methods value ranges from 0 to 1.

Table 4. Means and Standard Deviations for Navigational Method

Groups	n	M	SD	S. Error
Left Information Processors	34	.4048	.2271	.0390
Right Information Processors	34	.2751	.1717	.0294
Integrated Information Processors	34	.2797	.1665	.0286

A graphic comparison of the mean scores for navigational depth, path, and methods among left dominant information processors, right dominant information processors, and integrated information processors is presented in Figure 4.

Figure 4. Mean Scores for Navigational Patterns among Left Dominant Information Processors,



Right Dominant Information Processors, and Integrated Information Processors

Inferential Analysis

Three separate one-way ANOVA's were performed to determine whether there were significant mean differences in three different navigational patterns (navigational depth, path, and method) among left dominant information processors, right dominant information processors, and integrated information processors.

The independent variable in the present study was the information processing style of subjects, which had three levels: left, right, and integrated information processors. The dependent variables were the three different navigational patterns: (a) navigational depth patterns, (b) navigational path patterns, and (c) navigational method patterns.

Analysis of Demographic Data

One-factor ANOVA's were performed to determine whether there were initial differences between groups on several variables. There was no significant difference between groups on gender (F (2 ,90) = .770, p >.05), age (F (2 , 90) = .132 , p >.05), and year in college (F (2, 90) = .125, p >.05). There was also no significant difference between groups on previous computer training (F (2 , 90) = 1.998 , p >.05) and computer expertise (F (2 , 90) = 1.573, p >.05).

Information Processing Style and Navigational Depth Pattern

Null hypothesis 1. There is no significant difference in navigational depth patterns among left dominant information processors, right dominant information processors, and integrated information processors when navigating in a hypermedia environment.

Null hypothesis 1 was rejected. There was significant mean difference in the average of navigational depth among left dominant information processors, right dominant information processors, and integrated information processors (F (2 , 99) = 4.052 , p <.05).

Table 5. One-way ANOVA for Navigational Depth

Source	df	SS	MS	F	p
Between	2	.0018	.00089	4.052	.020
Within	99	.0022	.00022	--	--
Total	101	.0239	--	--	--

Post hoc Scheffè analysis indicated that the comparison between navigational depths for left dominant information processors and for the right dominant information processor was significant at the .05 level of significance.

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Table 6. Post Hoc Scheffè Analysis for Navigational Depth

Comparison of Navigational Depth	Mean Difference
Left versus Right	.0091*
Left versus Integrated	.0004
Right versus Integrated	.0087

*. The mean difference is significant at the .05 level.

Information Processing Style and Navigational Path Pattern

Null hypothesis 2. There is no significant difference in navigational path patterns among left dominant information processors, right dominant information processors, and integrated information processors when navigating in a hypermedia environment in terms of the degree of linearity.

Null hypothesis 2 was rejected. There was a significant mean difference in the average of navigational path among left dominant information processors, right dominant information processors, and integrated information processors in terms of the degree of linearity (F (2 ,99) = 4.089, $p < .05$).

Table 7. One-way ANOVA for Navigational Path

Source	df	SS	MS	F	p
Between	2	.103	.0513	4.089	.020
Within	99	1.241	.0125	--	--
Total	101	1.344	--	--	--

Post hoc Scheffè analysis revealed that the only comparison between navigational paths that was significant at the .05 level of significance was the comparison between navigational paths for right dominant information processors and for integrated information processors.

Table 8. Post Hoc Scheffè Analysis for Navigational Path

Comparison of Navigational Path	Mean Difference
Left versus Right	.0548
Left versus Integrated	.0220
Right versus Integrated	.0751*

*. The mean difference is significant at the .05 level.

Information Processing Style and Navigational Method Pattern

Null hypothesis 3. There is no significant difference in navigational method patterns among left dominant information processors, right dominant information processors, and integrated information processors when navigating in a hypermedia environment in terms of navigational methods they employ.

Null hypothesis 3 was rejected. There was significant mean difference in the average of navigational methods among left dominant information processors, right dominant information processors, and integrated information processors in terms of navigational methods they employ (F (2 ,99) = 5.075 , $p < .05$).

Table 9. One-way ANOVA for Navigational Methods

Source	df	SS	MS	F	p
Between	2	.368	.1840	5.075	.008
Within	99	3.589	.0363	--	--
Total	101	3.957	--	--	--

Post hoc Scheffè analysis revealed that the comparison between navigational methods for left dominant information processors and for the right dominant information processor was significant at the .05 level of significance. Post hoc Scheffè analysis also showed that the comparisons between navigational methods for left dominant information processors and for integrated information processors was significant at the .05 level of significance.

Table 10. Post Hoc Scheffè Analysis for Navigational Methods

Comparison of Navigational Methods	Mean Difference
Left versus Right	.1296*
Left versus Integrated	.1251*
Right versus Integrated	.0046

*. The mean difference is significant at the .05 level.

Discussion

The difference in the average of navigational depth among the three information processor groups seems to support the suggestion that right brain dominant subjects primarily approach problem solving tasks in an exploratory manner, while left brain dominant subjects approach problem solving tasks in predominantly systematic ways.

Right dominant information processing subjects, as expected, accessed significantly more new nodes than left dominant information processing subjects. This result is consistent with a similar study on cerebral hemisphericity and a Hypercard program conducted by McClusky (1993). McClusky reported that right brain dominant subjects outperformed the other groups (left brain dominant subjects and integrated subjects) in the number of new nodes visited within a Hypercard program.

On the basis of the findings of prior research in the field of hemispheric information processing preference and navigational patterns, the researcher expected that right dominant information processing subjects would prefer to interact with hypermedia systems in a relatively exploratory and comprehensive manner, visiting a large number of new nodes. In addition, surveying the literature also led the researcher to predict that left dominant information processing subjects would prefer to interact with the system in a systematic and conservative manner, accessing only very limited nodes. The result that right dominant information processing subjects accessed significantly more new nodes than did left dominant information processing subjects supports the researcher's expectations in conducting this study.

Given these results, it might be possible that right dominant information processing subjects explored the hypermedia system by actually accessing many different nodes beyond the nodes which were necessary to visit to perform the search tasks, while left dominant information processing subjects interacted with the system by accessing only the few nodes which were required to accomplish the search tasks. It is also likely that right dominant information processing subjects accessed a large number of new nodes freely because they would be less concerned about "getting lost" problem within the hypermedia because of their exploratory manner for problem solving. In addition, it is similarly likely that left dominant information processing subjects accessed very limited nodes because they would be very concerned "getting lost" problem within the hypermedia because of their conservative and systematic tendency of problem solving.

The observed frequencies indicated that integrated information processors visited a larger number of new nodes than left dominant information processors, though the difference between the two groups were not statistically significant. One possible reason the study failed to show a significant difference may be due to the relatively small sample size. This should be examined in future studies.

Although this result does not provide statistically significant support for the researcher's prediction, it still supports the fact that there is a difference in the navigational behavior of left dominant information processors and integrated information processors.

Other research on hemispheric preference for problem solving suggested that integrated information processors are individuals who simultaneously use the left and right dominant strategies in proportion appropriate for the situation. The results of this study might reflect that integrated information processors actually employed the left and right dominant strategies at the same time in proportion appropriate for the search tasks, while left dominant information processors employed predominantly the left dominant strategies.

The two types of search tasks, open-ended and closed-ended tasks, were given to the subjects to accomplish while they interacted within the system. The two different types of tasks were given in order to assist the subjects in using the hypermedia program purposely and comprehensively. The two different types of tasks were also given to keep the overall balance between the right dominant strategies and the left dominant strategies that would be demanded for accomplishing the tasks in the study. The open-ended tasks used in this research required users to respond in general terms based on their understanding of the overall content of the hypermedia system. Closed-ended tasks in this research required users to respond in specific terms that could be found on a certain screen in the hypermedia system. It was assumed that the open-ended tasks might require more of the right brain oriented problem solving strategies, while the closed-ended tasks might demand more of the left brain oriented problem solving strategies.

The results that integrated information processors visited a larger number of new nodes than left information processors might lead the researcher to infer that integrated information processors most likely employed the left and right brain dominant strategies in proportion appropriate for the two different types of search tasks, while left dominant information processors employed predominantly the left brain dominant strategies for the both types of search tasks.

The results of navigational path patterns, however, were contrary to the researcher's expectation. Right dominant information processing subjects followed significantly more linear paths than integrated information processing subjects. Right dominant information processing subjects followed a larger number of linear paths than left information processing style subjects, although not significantly.

The researcher expected that left dominant information processing subjects would prefer to navigate through the system using much more linear paths, while right dominant information processing subjects would prefer to interact with the system using relatively nonlinear paths. This assumption was based on information processing style research suggesting that left brain dominant processors are likely to approach problem solving tasks sequentially, while right brain dominant processors are likely to adapt different problem solving strategies such that they are likely to approach tasks non-sequentially.

It is difficult to interpret why the results of navigational path patterns of left and right dominant information processors were contrary to expectation in the current study. It might be possible that the contrary results were found for the navigational path patterns because the overall links needed to accomplish the search tasks were predominantly linear themselves. As a consequence, right dominant information processors who visited substantially more nodes for the search tasks in the study obtained higher scores in linearity value than did left information processors who accessed a lot less nodes within the hypermedia system. It is possible that right dominant information processing subjects would have outperformed left dominant information processing subjects in making linear links if the researcher had taken into consideration this aspect of A.g.i.l.e. Resource™ 's operation.

The difference in the average of navigational methods among three information processor groups supports the researcher's expectations in conducting this experiment. On the basis of the findings of research on brain hemisphericity and navigational patterns, the researcher assumed that left dominant information processing subjects would prefer to navigate within hypermedia systems using more analytical navigational methods such as using index and search functions. In contrast, the researcher expected that right dominant information processing subjects would navigate hypermedia systems using more holistic navigational features such as maps, hypertexts, and tables of contents.

The result that left dominant information processors employed a significantly larger number of analytical navigational methods than right dominant information processors confirmed the expectation of significant differences in the navigational methods employed among the three different information processor groups. The results are in agreement with the theory of information processing styles supporting that left brain dominant processors take predominantly analytical approaches to problem solving, while right brain dominant processors employ more likely holistic approaches for problem solving.

The findings for navigational methods in this study are similar to the findings of Leader & Klein (1996). Leader and Klein found that the field independent subjects [who are considered left dominant information processors] performed significantly better than the field dependent subjects [who are considered right dominant information processors] in using analytical navigational methods such as index and find functions in the experimental system. Indeed, left dominant information processing subjects in the present study also performed the search tasks employing substantially more of analytical navigational methods than right dominant information processors.

In addition, the findings of the present study indicated that integrated information processing subjects, as expected, used significantly more analytical methods than right dominant information processing subjects. This result also is in agreement with the findings of previous information processing research for integrated information processors. Information processing research suggested that integrated information processors are individuals who use simultaneously the left and right dominant strategies in proportion appropriate for the situation. The result of this study might reflect that integrated information processors employed the left and right dominant strategies at the same time while interacting within the system, while right dominant information processors employed predominantly right dominant strategies. The researcher assumed, based on the theory of information processing that integrated information processors would employ analytical methods and/or holistic methods in proportion appropriate in the situation for the two types of search tasks, while right information processors would employ predominantly holistic methods for both search tasks.

Conclusions

The results of the study provide insight into the relationships between navigational patterns and information processing styles of hypermedia users. These results, in turn, provide useful information for advising learners regarding selecting more efficient and effective navigational patterns, based on their information processing styles. In addition, the detailed information of users' navigational behaviors provides further guidance for designing hypermedia interfaces that would be more user-centered. The results of this study also verifies the effectiveness of hypermedia systems in terms of addressing individual differences. The findings of the present study led to the following general conclusions:

1. The present study demonstrates that the information processing styles seem to play an important role in how an individual interacts with hypermedia systems. The three different information processor groups used the hypermedia system in significantly different ways in terms of navigational behaviors. Left dominant information processors interacted with the system by visiting very limited nodes and employing a large number of analytical navigational methods, while right dominant information processors interacted with the system by accessing many new nodes and using a large number of holistic navigational methods. The navigational patterns of integrated information processors also confirmed the assumption that this group of users used simultaneously the left and right dominant strategies in proportions appropriate for the situation.

   It appears that the results of the present study provide valuable information for helping users navigate through hypermedia systems more efficiently. The results suggest that the information processing styles of hypermedia users can be translated into a practical guide on advising users in selecting more efficient and effective navigational strategies.

   If trainers know a trainee's information processing style prior to a training session or other instruction using a hypermedia system, they would be able to guide the different groups of information processors in using more efficient and effective navigational strategies for navigational depth, paths, and methods. Also, when an instructional task interacting with a hypermedia system seems to demand specifically left or right brain dominant information processing strategies, trainers or teachers should advise right dominant information processors to utilize left brain dominant strategies.

2. The indication of the significant relationships between hypermedia users' information processing styles and their navigational patterns in the present study would also provide further guidance for designing hypermedia interfaces which would be more user-centered.

   According to Sonnier (1984, 1985, 1989, 1992), hemispheric information processing preference is the basis for the common thread of individual difference in the ways in which human beings process information. In addition, in a variety of settings, it was verified that learners with different information processing styles could learn more and be better motivated if activities involving information retrieval accommodated the information processing approaches of those learners (Cafferty, 1980; Carbo, 1980; Douglass, 1979; Leader and Klein, 1996; McCluskey,1993). One of the goals in hypermedia interface design, then, should be to develop interfaces that are easy for a variety of users with different information processing styles to navigate the systems by applying the information processing strategies of those users. How should hypermedia designers design such an interface?

   The present study could provide some tentative conclusions to guide more user-centered hypermedia interface design that would be suitable for different user groups by supporting the variety of information processing styles of those users. In general, hypermedia designers and developers should take note of information processing style research when making design decisions related to navigation.

   Any decisions about which navigational methods to include in a hypermedia system should take into account the varying types of navigational strategies used by the three information processors. It is worth noting that left dominant information processors employed significantly more analytical navigational methods, while right dominant information processors used more holistic navigational methods. This discovery has an important implication for future design: the numbers of analytical and holistic navigational methods in a hypermedia system should be balanced, to a certain extent. Or, the unbalanced implementation of navigational methods between analytical methods and holistic methods, to a great extent, will benefit one of the information processing groups and exclude the other when utilizing hypermedia systems. Leader and Klein (1996) also suggested that interface designers should consider users' cognitive style factors in the use of hypermedia when they make decisions for the formulation of criteria for navigational methods.

3. The results of this study also provided additional information that is valuable to verify the effectiveness of hypermedia systems in terms of addressing individual differences in navigational strategies. Considerable educational research has demonstrated that the quality of learning can be enhanced when an instruction is matched to individual learning style (Carbo et al., 1986; Wilson, 1988; Barba and Armstrong, 1992; Billings and Cobb, 1992; Ellis et al., 1993; Larson, 1992; Lee, 1992; Liu, 1992; Overbaugh, 1992). Hypermedia has been proposed as one of the superior systems for achieving the goal of accommodating individual differences in learning style. The underlying assumption of nonlinear hypermedia systems is that different individuals will actively interact with the systems and the systems will accommodate individual differences in terms of various users' navigational preferences based on ones' learning styles.

   The results of this study support that hypermedia systems are effective learning tools to address individual differences on information processing styles of hypermedia users when navigating hypermedia systems. The study results indicate that the users were able to exploit the hypermedia system taking the navigational advantages of nonlinear structure provided by the hypermedia system according to their preferences of information processing styles.

In conclusion, the present study intended to discover the effect of information processing styles on the navigational behaviors of hypermedia users. The present study demonstrates that information processing styles seem to play an important role in how an individual interacts with the hypermedia system. It is hoped that this study contributes to the body of research on human-computer interaction in general and on navigational behaviors of hypermedia users in particular. The study provides some research-based guidance in designing future hypermedia applications and indicates direction for future research on navigational behaviors of hypermedia users. The conclusions of this study, however, should be considered suggestions not absolute prescriptions for designers or future researchers of hypermedia systems. The conclusions should be confirmed by additional research.

Hypermedia systems, used as sophisticated databases and instructional delivery systems, are becoming more powerful and hence more popular in educational and corporate environments. The current growth in the use of hypermedia both in education and corporate environment suggests that hypermedia system will most likely have an extensive impact on our lives. As the impact of hypermedia on our lives increases, educational technologists should continue research on how the various individuals actually utilize hypermedia and assist facilitation the use of hypermedia systems for all types of users in various environments of our lives.

Recommendations for Future Research

Further research is definitely needed for a comprehensive understanding of the issue of the different users and their specific navigational patterns of hypermedia systems. The following is a list of some possible directions for future research on this topic.

1. Future research should include a replication of this study across other age groups to see whether the results vary significantly from this study. For example, compare the differences between children and adult learners, or elementary school children and secondary students to see whether navigational patterns are different when comparing one age group to the other.
2. Future research should also include a replication of this study across other groups of subjects from different levels of familiarity with the content of the hypermedia system, Agility, to see whether the results vary significantly from this study. For example, to see whether subjects who are already somewhat knowledgeable in the area of agility navigate differently than those who are not.
3. Future research will also need to compare experienced and inexperienced users of hypermedia systems. The experienced users might have developed preferred patterns of navigation, while the inexperienced users have not. Then, there might be a difference in the way that these two different groups navigate through the material. In the present study, most of the subjects had used a computer through computer seminars, computer courses, or personal exploration with a computer in general, but only a few subjects were familiar with hypermedia systems. According to Barfield, Rosenberg, and Levasseur (1991), there exists a great deal of differences in users' interactions when subjects vary to a great extent in their computer experience.
4. In addition, future research should compare subjects with different learning demands. For example, see whether subjects who need to learn the material for a given test navigate differently from those who are simply evaluating the software.
5. Future studies should also investigate other hypermedia applications to see whether the results vary significantly from this study. It would be interesting to note differences between and among a variety of hypermedia programs using identical groups of subjects.
6. In future studies, that provide computer tasks, more tasks should be provided within each task unit. The present study only provided three open-ended tasks and five closed-ended tasks. The limited numbers of tasks were given because of the time constraints in the study.

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