Modelling User Navigation Behaviours in a Hypermedia-Based Learning System: An Individual Differences Approach

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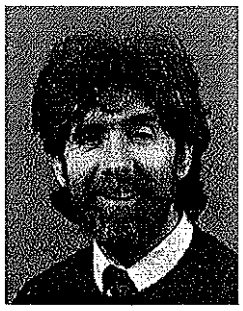


ABSTRACT: The rapid evolution of hypermedia technology makes it possible to access an immense volume of information in an educational setting. This research examines the relationship between individual differences (in particular, cognitive styles) and navigation strategies using a WWW-based hypermedia learning system. The hypermedia learning system was used at Sheffield University's Department of Information Studies. Twenty Masters students were pre-tested for their cognitive styles. Dependent variables included navigation patterns, selection of navigation tools, and reactions to the hypermedia system. The results indicated that students with differing cognitive styles and individual characteristics selected different access facilities and applied different navigation patterns. The implication of these findings and the role of individual differences in designing hypermedia-based learning systems are discussed.

1. Introduction

In an effort to increase the effectiveness of the use of hypermedia systems, the focus of recent research has shifted from system design to user interactions. In addition, an increasing number of studies examine individual differences and their effects on learning in hypermedia environments. *Hypertext or hypermedia* refers to the computer-based presentation of information in which links are inserted in a page of text and/or graphics which, when clicked by the user, present of the screen information related to that link. A simple example is a "clickable" table of contents. When the user clicks on a particular item, that item (e.g. a chapter or section) is immediately displayed on screen. Hypermedia refers to systems containing text, graphics and often sound and moving pictures. Hypertext refers to predominantly text-based systems (generally also including some graphical content). The term *hypermedia* is preferred to *hypertext* in this paper to refer to systems containing both text and graphics, including static as opposed to moving images. Hypermedia is used extensively in documents accessible via the World Wide Web. Individual differences in the context of the present paper include gender, subject knowledge and experience in particular subjects, and cognitive styles. Cognitive styles, introduced in section 2.2, are characteristic ways of processing information displayed relatively consistently by individuals.

Findings generally reveal that hypermedia has the potential to individualise instruction to meet the specific needs of learners (Rasmussen & Davidson, 1996). The primary reasons are that hypermedia systems can provide self-paced instruction and allow learners to use non-linear styles of access (navigating and browsing). Self-paced instruction refers to forms of instruction in which each learner can choose to learn at his or her own pace. Non-linear access means that learn-

ers are not forced to read information in one particular sequence, determined by the author of the instructional system. Rather, they are offered different choices at any particular point in a learning program, allowing them to determine which aspect of the subject matter to study next at any point in time.

Non-linear access is related to self-paced instruction in that both offer each learner the choice of speed and navigation route through the subject content. Such choices are related to the notion of individual differences in that the same instructional system can potentially offer each learner navigational choices suited to his or her particular needs. Such needs may differ from person to person. It has been suggested that non-linear knowledge access within hypermedia can enhance learning in comparison to relatively linear access. The extent to which this assumption is true is questionable. Exploration of the relationships between hypermedia's formal features and individual learner characteristics is needed if designers are fully to utilise the features of such applications to benefit individual learners.

This paper presents results of a research project that sought to explore the effects of individual differences on users' interactions within a hypermedia learning environment. The research sought to discover any significant correlations between certain individual differences (cognitive styles, gender and levels of Internet experience and prior subject knowledge) and navigation patterns in a hypermedia-based learning package. The ultimate goal of the research is to build a model linking individual differences, use of hypermedia navigation tools and learning outcomes. Such a model may enable intelligent systems to adapt to different individuals' needs by offering different navigational advice (e.g. by suggested "next moves") to enhance learning. However, the present study reported here is restricted to that part of the model linking individual differences with navigation strategies. Seeking links with learning outcomes will form the next stage of the research project.

The findings provide support for the notion that individual differences may have an effect on navigational patterns. It is concluded that understanding of individual differences may prove to be a useful component in the establishment of robust models of learning to support and guide the development of adaptive learning systems.

2. Theoretical Framework

2.1 Hypermedia-based Learning

The significance of utilising hypermedia for learning lies in its power to deliver large amounts of information in non-linear formats that relies on user-controlled choices during learning. By browsing and searching in hypermedia learning environments, learners can explore and interact with knowledge in personally meaningful ways. In this way, there is an inherent capability of delivering self-paced instruction that learners take full responsibility for their learning processes.

Arguably hypermedia has the potential to provide many benefits to learners, because the use of hypermedia is associated with the idea of learner control -- learners deciding which topics they will view, in what order they will view the topic, and how long they will spend on each topic. These elements of learner control may foster intrinsic motivation (Sweany, McManus, Williams, & Tothero, 1996). Spiro and Jehng (1990) remarked in their Cognitive Flexibility Theory that learning occurs by viewing the situation or problem from multiple perspectives. Effective instruction should provide materials which acknowledge these different viewpoints and which may be explored under the learner's control (Spiro & Jehng, 1990). Compared with previous Computer Aided Learning Programs (CAL), the capacity of hypermedia to access and organise knowledge is more similar to human knowledge acquisition (Jonassen, 1990).

On the other hand, there are problems that are specific to the organisation of hypermedia. One of the biggest problems is the fact that some students are uncertain of how to deal with non-linear programs. Non-linear structures allow a broad context and additional information that augments global learning (Gordon, 1992). Students with different learning styles and differing degrees of computing experience have been shown differentially to prefer linear and non-linear pathways through a hypermedia program (Reed & Oughton, 1998). Beishuizen, Stoutjedijk, and Putten (1994) found that beginners may get lost in complex hypertext and would be better served by directions on the part of the author. Repman, Rooze, & Weller (1994) indicated that students with different cognitive styles, specifically Field Dependence/Field Independence, were served differently by hypermedia-based instruction. Field Independent students learned more effectively than did Field Dependent students. Jonassen (1988) advocated that it is important to investigate how learners navigate through hypermedia systems and how individual differences could predict those paths. If learning environments can be aware of such differences, then they may be able to offer appropriate support, possibly resulting in higher quality learning.

2.2 Individual Differences

The different ways in which people learn and their different reactions to learning form a central core to

any learning program. Any student is capable of learning; not all are able to do so with equal effect. Therefore, an ideal learning program should take account of individual differences.

Many studies have shown evidence of individual differences and their significance in learning, ranging from gender differences (Ford & Miller, 1996, Francis, 1993), system experience (Marchionini and Liebscher, 1991), to cognitive styles (Liu & Reed, 1994; Leader & Klein, 1996). Among these differences, cognitive styles are especially related to the manner in which information is acquired and processed.

Witkin and Goodenough (1981) described the term *cognitive styles* as stylistic preferences consistently exhibited by individuals in the ways in which they organise, stimuli, and construct meanings for themselves out of their experiences. Cognitive styles can be classified in a variety of ways, such as Global-Holistic vs. Focused-Detailed, Field-Dependent vs. Field-Independent, Right-Brained vs. Left-Brained. This present research focuses on the dimension of Field Dependence and Field Independence, because it reflects one's mode of perceiving, remembering and thinking. Furthermore, it has emerged as one of the most widely studied cognitive styles with the broadest application to problems of education (Messick, 1976, Witkin & Goodenough, 1977). Relatively Field Dependent individuals tend to perceive objects as a whole, whereas the relatively Field Independent person tends to analyse the object into its component parts (Witkin & Goodenough, 1981). These differences would seem to be pervasive, extending from basic perception through to complex learning.

Research has already indicated the impact of Field Dependence on learning in hypermedia environments, but generally has not paid attention to Intermediate students (e.g. Weller, Repman, Rooze, 1994). There are probably some significant differences in how Intermediate students behave. Possession of an intermediate cognitive style may represent possession of a more versatile (and more effective) repertoire of learning approaches, because they may have both characteristics for Field Dependent and Field Independent Individuals. Another problem was that few studies have considered cognitive styles and other learners' individual characteristics together. In neglecting to study the interaction effects between individual characteristics and cognitive styles, there is a possibility of distortion developing in their findings and hence in their understanding of effects on the use of hypermedia learning systems.

The present research attempted to address the above two issues. The approach to these two problems in this study were (a) to include intermediate cognitive style as one of factors influencing students' individual differences on the use of hypermedia learning systems, (b) to analyse the correlations between learners' individual characteristics and cognitive styles through the interview and observation of their navigation strategies.

3. Research Design

3.1 Aims

Specifically, this pilot study aimed to investigate whether there were significant correlations between individual differences and preferred types of navigation tools and navigation patterns.

3.2 Population

The participants (N=20) consisted of Masters' students who registered for the Information Storage and Retrieval course at Sheffield University's Department of Information Studies. They were 10 males and 10 females. Eleven participants were overseas students, , who came from Africa, Malaysia, Singapore, Italy, Greece, and Hong Kong, etc. and the rest were British students. The computer experience and Internet experience reported by the participants varied from fair to excellence. Their familiarity with the subject content, *An Introduction to Artificial Intelligence*, ranged from fair to average.

3.3 Choice of Variables

Previous research has found links between styles of learning and field-dependent/-independent cognitive styles (e.g. Witkin et al., 1977), between gender, age, cognitive style and differences in perceptions and behaviour when searching for information on the Internet (Ford and Miller, 1996). For this reason, there variables were selected as potentially significant in determining students' interaction with a hypermedia learning package.

Since it was not clear how individual differences might manifest themselves in this hypermedia environment, it was decided to collect data on as wide a range of navigational behaviour as possible. The following parameters of behaviour were therefore included as variables:

1. The frequency of navigation tools selected:
   including referenced links, section buttons, Previous/Next buttons, Back/Forward buttons, and Main Menu, and
2. Feedback on the system was also sought in terms of:
   - Reactions to the system, including structure, volume, and depth;
   - Degree of confidence; and
   - Disorientation problems.

   These issues were identified at three levels.

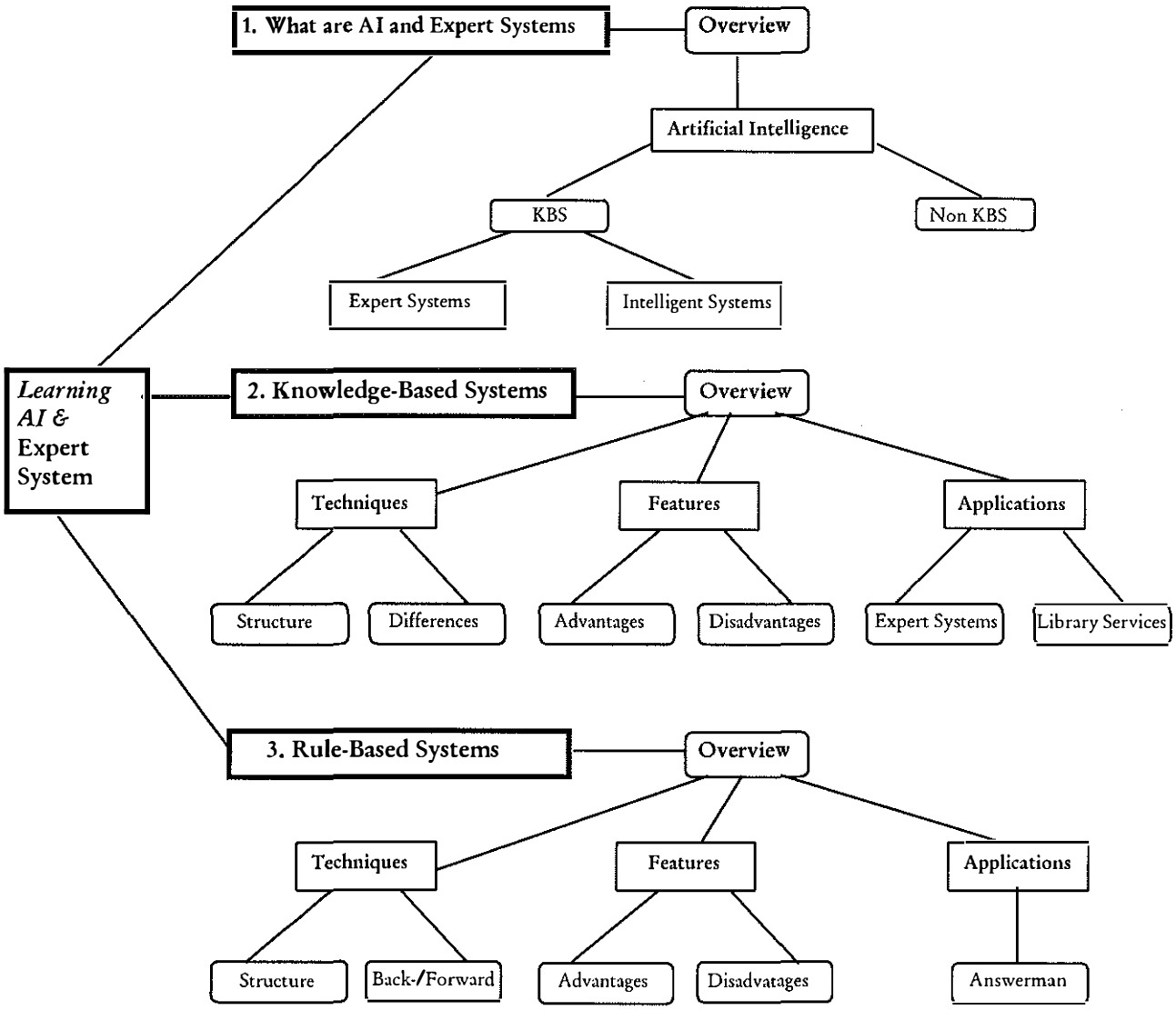


Figure 1: Structure of Subject Matters

3. The mean scores for the items below:
   - Pages Browsed: (Number of pages visited);
   - Navigational Moves: (Number of navigation actions i.e. clicking a button or hyperlink);
   - Duplication of Pages Visited: (The number of times the same page was visited);
   - Information Processing Time: (Time spent exploring the hypermedia system);
   - Hierarchical Depth: (Figure 1 shows hierarchical levels of the subject matter).

In view of the opinions of researchers such as Linard and Zeiliger (1995), and Small and Grabowski (1992), that prior knowledge and experience are important determinants of learning behaviour, it was also decided to include variables relating to the students' prior knowledge of the subject content of the learning package, and their prior experience of using a hypermedia browser to access information. Since use of the Internet generally entails accessing information on the World Wide Web using the same or a similar browser to that used to create the hypermedia system in the present research (Netscape Navigator), students were asked to indicate their level of experience of Internet use.

3.4 Material & Apparatus

3.4.1 Cognitive Styles Analysis

Riding's (1991) Cognitive Styles Analysis (CSA) was used to identify students' cognitive styles in this study. The CSA measures wholist/analytic dimensions of cognitive style - equivalent to field dependence/-independence (Ford, 1995) introduced in section 2.2, and offers computerised administration and scoring. The CSA includes two sub-tests. In the first, participants are required to judge the similarity of a series of complex geometrical figures. The second requires the participants to determine whether a simple shape is contained within a complex geometrical figure.

Riding's recommendations are that the scores below 1.03 denote Field Dependent individuals; and that scores of 1.36 and above denote Field Independent individuals. Participants scoring between 1.03 and 1.35 are classed as Intermediate (Ford, 1996). These recommendations were followed in the present study.

3.4.2 Hypermedia Program

Students interacted with a hypermedia program entitled *An Introduction to Artificial Intelligence*. The contents were divided into three sections: (a) What are AI and Expert Systems? (b) Knowledge-based Systems, and (c) Rule-Based systems. Each of the three sections was further split into four parts, including (a) overview of concepts; (b) description of techniques; (c) examples of applications; and (d) advantages and disadvantages. The teaching/learning approach in this hypermedia program was based on the concept of self-organised learning. In other words, students were allowed freedom to choose their own navigational routes through the subject matter. Topics and subtopics could be studied in any order. Two main types of learner control were available in this package. These were: (1) Sequence Control: to allow students to decide the sequence of topics to be learned using different navigation tools; and (2) Content Control: to allow students to choose different aspects of each sub-topic, for example, applications, disadvantages and advantages. In this way, students were forced to decide what to do and in what order. The rationale for adopting this approach was as follows.

1. In order to discover any effects of individual differences on navigation strategies, it was necessary to allow students to express their choices as freely as possible.

2. It would be important to discover whether certain types of learner (e.g. with a particular cognitive style) might choose differentially effective navigation strategies. Such differences would not be visible if the system imposed what the authors considered to be a pedagogically effective navigation route. (It is acknowledged that this consideration is relevant to the next stage of the research, which will investigate learning outcomes, and not to the stage of the research presented here.)

3. Student choice of navigation patterns is generally greater in hypermedia systems than other more traditional forms of computer assisted learning packages. In view of the explosion of interest in delivering training and education using hypermedia, especially over the World Wide Web, it was considered important to study the effects of allowing students such freedom.

In this way it was intended that students' preferred navigation strategies and learning approaches could be observed. Figure 2 illustrates the structure of the hypermedia learning environment.

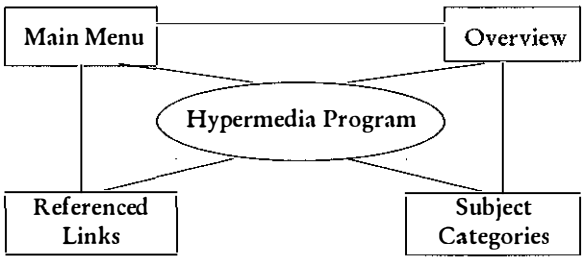
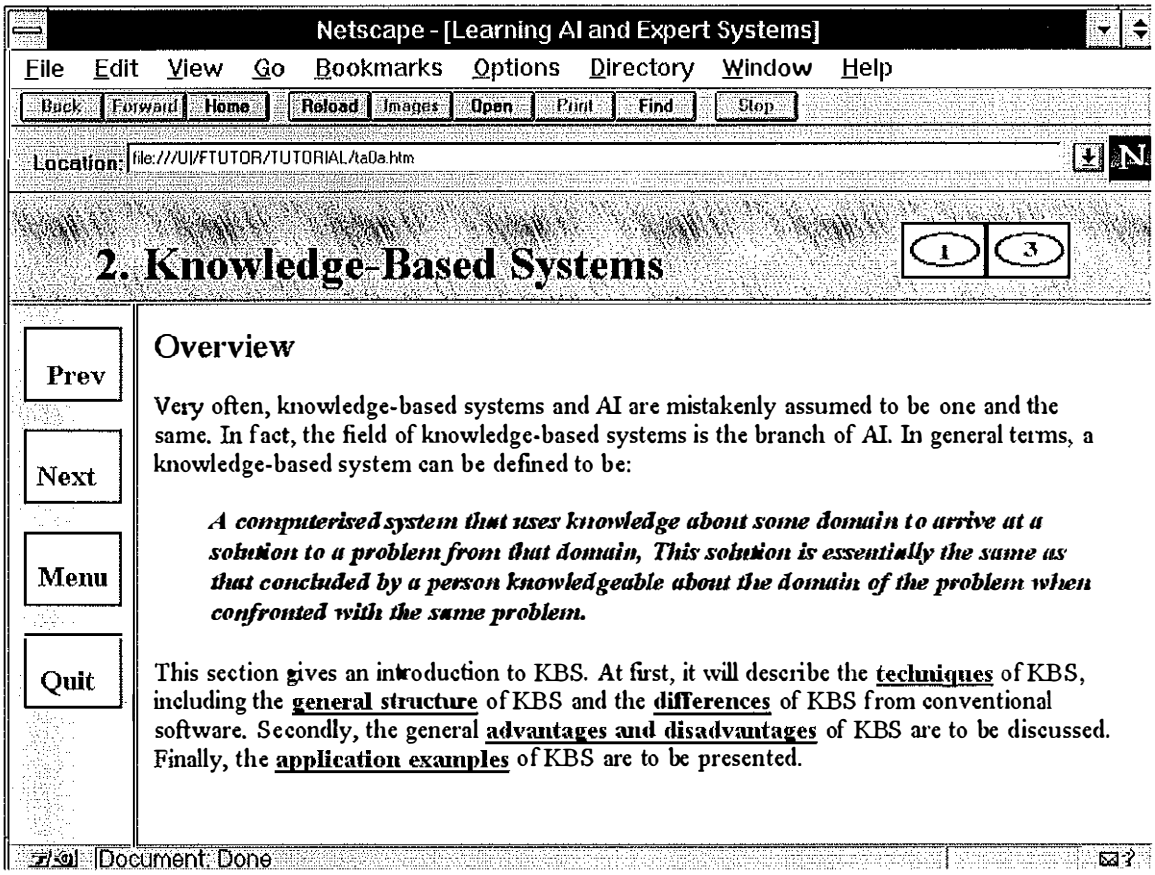


Figure 2: Structure of the Hypermedia Program

Screens included: (a) a title bar located at the top of the screen showing the section name being viewed and the other available section buttons; (b) a control panel with the choices for Main Menu, Previous/ Next and Quit buttons, and (c) the main body of the program providing referenced links and subject categories for selection.

The Main Menu presented all of the section names and numbers in the system. Students could click the section numbers or names to view that section. Each section included an introductory overview. Students had the options to see the *page* previously viewed using Previous/Next buttons and view the *section* last visited using Back/Forward buttons Netscape browser provided. Figure 3 displays the screen design of this hypermedia program.

Figure 3: The Screen Design of the Hypermedia Program



3.5 Procedures

The experiment was conducted from October 1997 to December 1997. The following procedures were applied:

Step 1: Participants in this research were asked to take Riding's Cognitive Styles Analysis (CSA) test to determine their cognitive styles, i.e. Field Dependent, Intermediate, or Field Independent (Riding, 1991).

Step 2: Each participant was interviewed to gather demographic information, such as age, subject knowledge, Internet experience, study program, etc.

Step 3: Participants interacted with the hypermedia program. Navigation patterns were logged and analysed, including (a) selection of navigation tools and (b) sequence of navigation. There was no time limit for participants, but the average time spent was 30 minutes (minimum: 17.5 minutes, and maximum: 44.3 minutes).

Step 4: Participants were interviewed to identify learning experiences and feedback on the hypermedia program. The interview covered: (a) reactions to the program, including the depth, volume, and structure, (b) the degree of confidence of understanding of the subject matters, and (c) orientation and disorientation.

As mentioned in the *Introduction*, learning effects were not measured in the stage of the research reported here. Links between individual differences, navigation patterns and learning outcomes will form the main focus of the next stage of the research, yet to be conducted.

3.6 Analysis of Data

To answer the question: "What is the relationships between individual differences and their navigation behaviours in a hypermedia learning system", the following types of data analyses were conducted:

1. to connect students' feedback on the system with their cognitive styles.

2. to assess the relationships between frequency of navigation tools selected and cognitive styles.

3. to discover students' navigation patterns derived from their navigation routes, including pages browsed, navigation moves, Duplication of Pages Visited, Hierarchical Depth, information processing time and to seek any correlation with learning styles.

The above data analyses were also conducted to find any correlation with gender, subject knowledge, and Internet searching experience. The intention was to find which conditions are of benefit for the use of hypermedia learning program.

Statistical analysis of the data was conducted using SPSS for Windows version (release 6.0). Pearson's *r* was applied to find the correlations between these variables. *r* close to 1.0 implies a strong positive relationship, *r* close to zero implies no relationship, and *r* close to -1.0 implies a strong negative relationship (Babble & Haley, 1994).

4. Analysis of Results

Table 1 illustrates the distribution of cognitive styles within the subject group:

Cognitive Styles	Female	Male	Total
Field Independent	4	3	7
Intermediate	4	4	8
Field Dependent	2	3	5
Total	10	10	20

Table 1: Cognitive Styles of the Population

4.1 Cognitive Styles

From Table 2 to Table 4, the results of three separate groups are given. The first analysis categorised all the data into Field Independence/Not Field Independence; the second into intermediate/Not Intermediate; and the third into Field Dependence/Not Field Dependence. Therefore correlations for a given cognitive style relate to possession of that cognitive style versus non-possession of that style.

The correlations between students' cognitive styles and their selection of navigation tools are presented in Table 2. (In tables 2-7, asterisks denote levels of statistical significance.) Field Independent students made significantly less use of the Main Menu and Previous/Next buttons than Field Dependent students and Intermediate students. Reference links seemed to be favoured by Intermediate students. Field Dependent students used the Main Menu more often than the others.

4.1.1 Selection of Navigation Tools

	Field Independence (N=20)	*Intermediate* (N=20)	*Field Dependence* (N=20)
Navigation Tools	Positive r= Field Independence	Positive r= Intermediate	Positive r= Field Dependence
Main Menu	r=-.5059 *p=0.023	r=.0768 p=0.748	r=.4704 *p=0.036
Referenced Links	r=-.4371 p=0.054	r=.6588 **p=0.002	r=-.2638 p=0.261
Previous/ Next Buttons	r=-.4891 *p=0.029	r=.1154 p=0.628	r=.4082 p=0.074
Back/Forward Buttons	r=.0585 p=0.807	r=.2643 p=0.260	r=-.3635 p=0.115
Sections Buttons	r=-.0553 p=0.817	r=.4427 p=0.051	r=-.4400 p=0.052

(* : significance level .05; ** : significance level . 01)

Table 2: Correlations between Cognitive Styles and Selection of Tools

Field Dependent students made significantly greater use of the Main Menu and conversely Field Independent students made significantly less use of this facility. Arguably, the use of the Main Menu signifies an interest on relatively global aspects of navigation, since the Main Menu gives an overview of all available topics. The significant lack of use of the Main Menu by Field Independent students may signify a relative lack of interest in global aspects of navigation and a more specific focus. Field Independent students would also seem to be less interested in being guided insofar as they display significant less use of the Previous/Next buttons which at least partially represent guidance as to what should be read next on the part of the system designer. High levels of use of referenced links by Intermediate students could arguably be seen as indicating high levels of engagement with the subject content, in that referenced links represent interest in "follow up" information relevant to the particular subject content being read at the time (more than reversion to the more general topics in the Main Menu). There were not, however, significant differences in accessing the section buttons and Back/Forward buttons.

4.1.2 Navigation Patterns

	Field Independence (N=20)	*Intermediate* (N=20)	*Field Dependence* (N=20)
Navigation Patterns	Positive r= Field Independence	Positive r= Intermediate	Positive r= Field Dependence
Pages visited	r=-.3568 p=0.123	r=.8024 **p=0.00	r=-.5149 *p=0.020
Navigational moves	r=-.5636 **p=0.010	r=.6310 **p=0.003	r=-.0930 p=0.696
Pages duplicated	r=-.5657 **p=0.009	r=.4406 p=0.052	r=.1246 p=0.601
Information Processing Time	r=-.1664 p=0.483	r=.3811 p=0.097	r=-.2478 p=0.292
Hierarchical Depth	r=-.1372 p=.564	r=.6633 **p=.001	r=-.5993 **p=.005

(* : significance level .05; ** : significance level . 01)

Table 3: Correlations between Cognitive Styles and Navigation Patterns

A number of significant correlations were found for navigation patterns. Field Independent students navigated the hypermedia package with less navigational duplication than other students. Intermediate students browsed significantly more pages, made more moves, and explored levels of content deeper in the hierarchical structure. Field Dependent students browsed fewer pages and concentrated on surface levels in the subject hierarchy. No significant differences were found between cognitive styles and information processing time. Table 3 gives details of these correlations.

4.1.3 Reactions to the System

It is interesting to find that students with different cognitive styles responded differently to program features (Table 4). The results indicated that Field Independent students thought the structure of this hypermedia system was logical. Intermediate students regarded content as too superficial. On the other hand, Field Dependent students felt that the amount of the contents was too large and judged the content too detailed and experienced disorientation problems. These results may imply that Field Dependent students had difficulties in learning in this hypermedia environment.

	Field Independence (N=20)	*Inter-mediate* (N=20)	*Field Dependence* (N=20)
Reactions to the System	Positive r= Field Independence	Positive r= Intermediate	Positive r= Field Dependence
Structure of the Contents logical	r=.4746 *p=0.034	r=.0828 p=0.729	r=-.4292 p=0.059
Amount of the Contents just right	r=-.3111 p=0.182	r=.7013 **p=0.001	r=.4508 *p=0.046
Depth of the Contents just right	r=-.0955 p=0.689	r=.5581 *p=0.011	r=.5262 *p=0.017
Disorientation Problems experienced	r=-.1961 p=0.407	r=-.2182 p=0.355	r=.4696 *p=0.040
Confident in Understanding	r=.707 p=.767	r=.0000 p=1.000	r=-.0778 p=.744

(* : significance level .05; ** : significance level . 01)

Table 4: Correlations between Cognitive Styles and Reactions to the System

4.2 Other Characteristics

4.2.1 Selection of Navigation Tools

	Internet Experience (N=20)	Subject Knowledge (N=20)	Gender Differences (N=20)
Navigation Tools	Positive r= with a lot of experience	Positive r= with a lot of knowledge	Positive r= male students
Main Menu	r=.1908 p=0.420	r=-.0013 p=0.996	r=.0209 p=0.930
Referenced Links	r=.4827 *p=0.031	r=.5660 **p=0.009	r=-.0571 p=0.811
Previous/ Next Buttons	r=-.5184 *p=0.019	r=-.2053 p=0.385	r=.1414 p=0.552
Section Buttons	r=.1566 p=0.510	r= .4477 *p=0.048	r= .0000 p=1.000
Back/Forward Buttons	r=.6628 **p=.001	r=.6142 **p=.004	r=.0180 p=.940

(* : significance level .05; ** : significance level . 01)

Table 5: Correlations between Other Characteristics and Selection of Tools

Table 5 shows that students with more Internet experience made greater use of the Back/Forward buttons and reference links. On the other hand, there was a significant negative relationship between the number of times students made use of the Previous/Next buttons and their Internet experience. The Back/Forward buttons were those provided by the Netscape Navigator browser, whereas the Next/Previous buttons were designed by the learning program. They were provided in order to give full navigational control from the actual pages of the program. Possibly students with Internet experience were familiar with the Netscape browser, so they felt comfortable and confident to use the in-built Back/Forward buttons. If it was the case that these experienced were simply using their preferred access method, this finding would concur with the observation of naive users noted by Oliver and Oliver (1996).

There were also significant links between subject knowledge and the frequency of use of navigation tools. When students had more subject knowledge, they used more reference links, section buttons, and Back/Forward buttons. It is possible that they wished to locate more specific information than those with less experience, since reference links appearing within the text tend to refer the reader to relatively specific items of information compared to the main menu, and the Back/Forward and section buttons. No interaction between selection of navigation tools and gender was found.

4.2.2 Navigation Patterns

	Internet Experience (N=20)	Subject Knowledge (N=20)	Gender Differences (N=20)
Navigation Patterns	Positive r= with a lot of experience	Positive r= with a lot of knowledge	Positive r= male; negative=female
Pages Browsed	r=.1572 p=0.508	r=.6238 **p=0.003	r=-.1274 p=0.592
Navigational Moves	r=.4816 *p=0.032	r=.5576 **p=0.011	r=.0293 p=0.902
Duplication of Pages Visited	r=.3703 p=0.108	r=.3406 p=0.142	r=.1032 p=0.665
Information Processing Time	r=.4916 *p=0.028	r=.5836 *p=0.07	r= -.5383 *p=0.014
Hierarchical Depth	r=.3730 p=.105	r=.6865 **p=.001	r=-.2256 p=.339

(* : significance level .05; ** : significance level . 01)

Table 6: Correlations between Other Characteristics and Navigation Patterns

Table 6 describes the effects of other characteristics on navigation patterns. Male students took significantly less time than female students. From the observations of the investigator, it appeared that females looked at each page in more detail than males.

There were significant correlations between students' Internet experience and the number of pages browsed, number of navigational moves, and information processing time. Participants with a lot of Internet experience spent longer interacting with the hypermedia system. It may be that they were more interested in the system, since they were familiar with various navigation tools and navigation strategies.

Correlations were also found between levels of subject knowledge and the number of pages browsed, navigational moves, level of depth explored in the subject hierarchy, and information processing time. Possibly levels of subject knowledge influenced learning motivation.

4.2.3 Reactions to the System

	Internet Experience (N=20)	Subject Knowledge (N=20)	Gender Differences (N=20)
Reactions to the System	Positive r= with a lot of experience	Positive r= with a lot of knowledge	Positive r= male; negative=female
Structure of the Contents	r=.2477 p=0.292	r=-.0013 p=0.996	r=.3379 p=0.145
Amount of the Contents	r=.2232 p=0.344	r=.7985 **p=0.000	r=.0000 p=1.000
Depth of the Contents	r=.4773 *p=0.033	r=.5999 **p=0.005	r=.0000 p=1.000
Disorientation Problems	r=.3155 p=0.175	r=-.2024 p=0.392	r=-.5345 *p=.015
Confident in Understanding AI	r=.1257 p=.598	r=.3830 p=.096	r=.5394 *p=.014

(* : significance level .05; ** : significance level. 01)

Table 7: Correlations between Other Characteristics and Reactions to the System

Students who had a lot of Internet experience thought the depth of the contents too superficial. Moreover, there were significant relationships between students' subject knowledge and views on (a) the amount of content and (b) the depth of content. Students with more subject knowledge thought the contents of this hypermedia system too brief and superficial. These findings are not particularly unexpected. However, more surprising were significant correlations suggesting that males felt more confident in their understanding whilst females experienced more disorientation problems. The latter finding does

concur with that of Ford and Miller (1996). In a survey of students' perceptions and usage of the Internet, they also found that women reported significantly more disorientation than males when searching for information on the World Wide Web. This is difficult to interpret. It may be that women feel less comfortable in this type of computer-based environment. Or it may simply be that women felt more able to be honest in reporting difficulties, men possibly being more reticent about admitting to such problems. Clearly, further research is needed in this area.

5. Discussion

Hypermedia, as an information presentation and representation system, possesses four distinctive characteristics: non-linearity, associativity, flexibility, and efficiency (Liu, 1992). The hypermedia learning program used in this research incorporated these four features in its design. Learners had control over the choice of different navigation tools and how to proceed in order to meet their learning objectives. The research found that students with different cognitive styles and characteristics employed different navigation strategies within this hypermedia learning environment. These findings are line with previous research studies showing that individual differences influence navigation behaviours (Liu & Reed, 1994, Wang & Jonassen, 1993, Leader & Klein, 1996). The findings of the current research are summarised below:

5.1 Passivity of Approach

The choice of navigation tools by students participating in this research indicated that Field Dependent students tended to make heavy use of the Main Menu, unlike their Field Dependent counterparts. According to Witkin, et al. (1981), Field Dependent students tend to adopt a more passive approach to learning and to require more structure and guidance. Arguably, high use of the main menu could be considered as reflecting greater need for authoritative guidance, although further research will be required to shed light on such issues.

Those students with greater experience of Internet use or subject knowledge, made more use of using reference links and the Back/Forward buttons. This finding arguably supports Linard and Zeiliger's (1995) suggestions that every learner using a new hypermedia system needs to be supported by an initial phase of orientation and initiation relating to both interface and domain contents. It is possible that since those students who had more Internet experience or subject knowledge felt familiar with the interface and the contents of the hypermedia program, they were able to be more active when navigating the hypermedia system.

5.2 Coverage of Browsing

Relatively Intermediate students and those with relatively high levels of subject knowledge browsed significantly more pages than others in this research. If the number of pages browsed can be associated with the coverage of the contents learned, then Intermediate students and students with high levels of existing knowledge on this subject seemed to pay attention to a broader range of topics when exploring the hypermedia system. One possible interpretation is that possession of an Intermediate cognitive style represents possession of a more versatile repertoire of learning approaches, including both global and local strategies resulting in more extensive coverage. One might expect superior levels of subject knowledge to be allied to superior coverage when interacting with the hypermedia system.

On the other hand, Field Dependent students considered the volume and level of detail of the information difficult to deal with. This is in accord with Witkin et al.'s (1977) findings that Field Independent individuals are more able to engage in learning requiring independent analytical thought. It is possible that more guided access to the contents would be useful in assisting Field Dependent students, who may be less adept at such types of learning.

5.3 Depth of Exploring

This research indicated that not only did Intermediate students cover more content, but also went to deeper levels in the subject hierarchy. On the other hand, it is interesting to note that Field Dependent students were linked to exploration at relatively surface levels of the subject hierarchy. This finding is again consistent with Witkin, Moore Goodenough, and Cox's view that Field Dependent learners tend to employ a global, spectator and less analytic approach to learning (Witkin, Moore Goodenough, & Cox, 1977).

Through analysing the students' subject knowledge, one thing seems evident. When students were lacking background knowledge of the subject content, they were either not capable of or interested in exploring deeper levels of content. It is interesting to note that Small and Grabowski (1992) consider that the decisions students make are influence by personal or environmental constraints, such as prior experience, or the type or amount of information available. It would seem in the case of the present research that student's existing knowledge did seem to influence their interaction with the hypermedia learning sys-

tem. There would seem to be a need for more research aimed at investigating how to assist students with low levels of prior subject knowledge.

5.4 Efficiency of Learning

When examining each student's navigation path in this research, it would seem that Field Independent students learned more efficiently than did Field Dependent or Intermediate students, in that they tended to make less navigational moves overall, to engage in less duplication when visiting pages, and to make less use of the Previous/Next buttons - despite exploring deeper levels in the subject hierarchy and reporting fewer problems with the volume and depth of content than their Field Dependent counterparts.

In addition, students' gender, levels of Internet experience, and subject knowledge were all significantly correlated with time spent interacting with the hypermedia system. Female students spent significantly more time than male students, as did students with a relatively high level of subject knowledge, and those with high levels of Internet experience. It might be expected that browsing more pages overall would be linked with total time spent interacting with the system. However, the appearance of significant differences relating to gender is interesting. It may be that factors relating to the interaction between researcher (female)and students (males and females) may have had some effect here. This possibility is one of a number of suggestions emerging from this pilot study which will guide the design and refinement of the research design for the main study.

6. Conclusions

This research sought to examine, within a hypermedia learning environment, the notions that students acquire information using different navigation strategies, and that these differences may be linked to individual differences. The results would seem to support these notions, in that differences in the use of navigational tools were linked to cognitive styles, level of subject knowledge and Internet experience. It is also interesting that overall coverage of subject content, depth of exploration and levels of disorientation were also linked with gender, subject knowledge and Internet experience.

Arguably, decisions about the design and inclusion of navigation tools in user interfaces should take into account students' individual differences. Tools providing structure and guidance may be more important for relatively Field Dependent individuals, whereas rich use of referenced links and other means for obtaining relevant information would be especially benefit to those students with an Intermediate or Field Independent cognitive styles. It is possible that students could learn more efficiently and effectively, and perhaps be better motivated, if learning environments could be tailored – or even adapt dynamically – to their particular individual characteristics.

A number of limitations of this research should be noted, in particular the small sample size; and the restricted design of the hypermedia system's navigation tools. These findings have nevertheless been useful in offering some support for the original decision to focus on individual differences in that significant effects have been found even in such a small sample. The findings from this pilot study will be further investigated. The next stage of the research will:

1. extend the navigation tools;
2. use a larger sample of some 80 students;
3. take into account students' task perceptions;
4. consider students' types and levels of motivation;
5. allow different levels of freedom to determine navigational control;
6. measure students' learning performance.

Computer-based instructional systems capable of accommodating different learning approaches according to different individuals' preferences and needs may arguably improve the students' performance, shorten study time, and improve attitude toward learning (Chinien, 1993). More research is needed in order to build robust models of the interactions between learners and flexible computer-based systems. Such knowledge will be useful to system designers, and may lead to improved adaptive systems capable of improving learning by allowing learners to choose (or indeed be guided to) levels and types of interaction suited to their particular needs and characteristics.

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