The Role of Individual Differences in Internet Searching: An Empirical Study

Nigel Ford, David Miller, and Nicola Moss
Department of Information Studies, University of Sheffield, Regent Court, 211 Portobello, Sheffield S10 4DP, UK. E-mail: {n.ford,d.miller}@sheffield.ac.uk

This article reports the results of a study of the role of individual differences in Internet searching. The dimensions of individual differences forming the focus of the research consisted of: cognitive styles; levels of prior experience; Internet perceptions; study approaches; age; and gender. Sixty-nine Masters students searched for information on a prescribed topic using the AltaVista search engine. Results were assessed using simple binary relevance judgements. Factor analysis and multiple regression revealed interesting differences, retrieval effectiveness being linked to: *male gender*; *low cognitive complexity*; an *imager* (as opposed to *verbalizer*) *cognitive style*; and a number of Internet perceptions and study approaches grouped here as indicating *low self-efficacy*. The implications of these findings for system development and for future research are discussed.

Introduction

Increasing Internet access is bringing the need for information seeking skills to an increasing volume and diversity of end users. However, Internet-based information seeking is in important respects very different from those characteristic of more "traditional" information environments (Jansen & Pooch, 2001). In particular, the Internet provides a context in which "the collection" of documents is subject to constant, rapid, and unsupervised change, and the mediated communication paradigm of human indexers targeting known groups of potential users is becoming decreasingly common (Ellis, Ford, & Furner, 1998).

We urgently need to increase our knowledge of factors that influence the effectiveness of Internet-based information seeking. Knowledge specific to one or other system, or to the state of the Internet at a particular point in time, is unlikely to be particularly useful in a longer term context. We need knowledge of more fundamental and enduring factors that can help us improve people's Internet retrieval in deep and lasting—as opposed to relatively superficial and fleeting—ways.

The present article reports the analysis of an AltaVista search conducted by 69 Masters students as part of a project funded by the United Kingdom Arts and Humanities Research Board that sought to investigate the role of "individual differences" (described in detail below) in Internet searching.

Background

Cognitive Styles and Study Approaches

There is evidence (e.g., Entwistle, 1981; Ford, 1985a, 1985b; 1995; Ford & Chen, 2000; Ford & Ford, 1993; Pask, 1976a, 1976b, 1976c, 1979, 1988; Pask & Scott, 1972; Robertson, 1977; Witkin, Moore, Goodenough, & Cox, 1977) that suggests that: (a) different individuals seek and process information using very different strategies; (b) different strategies may be more, or less effective for different people in different contexts; and (c) individuals may to some extent be "typed" by a consistent tendency to adopt one or other type of information processing strategy (such tendencies being termed *cognitive styles*).

Many such cognitive styles have been identified (Brumby, 1982; Jonassen & Grabowski, 1993; Miller, 1987; Riding & Cheema, 1991; Schmeck, 1988). However, Riding and Cheema (1991, p. 210) conclude, on the basis of a comparative review, that:

> there are two basic dimensions of cognitive style: (1) the wholist-analytic style of whether an individual tends to *process* information in wholes or in parts; and (2) the verbal imagery style of whether an individual is inclined to *represent* information during thinking verbally or in images.

A particularly well-established, and widely studied, manifestation of wholist/analytic differences is Witkin's *field-dependence*. Witkin and others have investigated wholist/analytic differences in a very wide range of human activity

Received July 3, 2000; Revised March 22, 2001; accepted April 11, 2001

from basic perception through academic success to career choice (Witkin, Moore, Goodenough, & Cox, 1977). Relatively field-*independent* individuals are more adept at structuring and analytic activity relative to field-*dependent* individuals. Field-independent individuals tend to experience the components of a structured field analytically, as discrete from their background, and to impose structure on an unstructured field. By contrast, relatively field-dependent individuals tend to be less good at such structuring and analytic activity, and to perceive a complex stimulus globally as a gestalt. This dimension would seem to extend from perceptual through intellectual and social functioning. The other main dimension of cognitive style according to Riding and Cheema (1991) is the *verbalizer/imager* distinction. As the name of the style suggests, individuals located towards one or other pole of the dimension will tend to perform better in tasks that require the associated form of information representation in memory—visual or verbal. This dimension of cognitive style has received less research attention than that relating to the wholist/analytic distinction.

There is also evidence of consistent differences in study approaches—that is, the way in which different individuals approach the task of learning. A central figure in research into study approaches is Noel Entwistle, who, over many years has developed progressive versions of an inventory designed to measure key dimensions of study approaches (Entwistle, 1981; Entwistle, Hanley, & Hounsell, 1979; Entwistle & Tait, 1990; Richardson, 1990; Tait & Entwistle, 1995). One of the most pervasive is that of *deep*, *surface*, and *strategic* approaches. A *deep approach* consists of the following subscales: intention to understand (as opposed to *memorize* and *reproduce* material learned); active interest (following up and questioning ideas for oneself); relating ideas (linking ideas together to form an overall picture); and use of evidence (carefully examining the detailed evidence supporting the overall picture). A *surface approach* consists of: intention to reproduce (as opposed to attempting to extract meaning); passive learning (accepting ideas passively without thinking about them for oneself); unrelated memorizing (memorizing facts and details without fitting them into a broader overall picture—the pathological counterpart to *use of evidence*); and fear of failure (anxiety-led motivation). A *strategic approach* consists of: intention to excel (achievement-led motivation); and effective time management.

Cutting across the deep/surface/strategic distinction is a dimension deriving from the work of Pask, which to some extent echoes Witkin's wholist/analytic cognitive styles. For a more detailed discussion of the differences and similarities between the constructs of Witkin and Pask the reader is referred to Ford (1995). Based on an extensive series of experiments (Pask, 1976a, 1976b, 1976c, 1979, 1988; Pask & Scott, 1972), Pask argues that individuals may display general tendencies to adopt a wholist or an analytic approach, depending on the strength to which they possess two distinct components of understanding. Comprehension learning (Pask's term for a wholist approach) entails *description building*—necessary to obtain a conceptual framework. Operation learning (Pask's term for an analytic approach) consists of *procedure building*—necessary to establish detailed evidence supporting and justifying the conceptual framework.

Individuals may tend generally to prefer, and be better at, one or the other. Individuals displaying a wholist comprehension learning style emphasize description building. Those displaying an analytic operation learning style emphasize procedure building. Individuals displaying a versatile learning style show neither imbalance, and achieve full understanding by successfully engaging in both approaches. The extreme comprehension learner may fail to engage in procedure building to such an extent that s/he displays the learning pathology *globetrotting*—overgeneralizing and failing to support an overview sufficiently with appropriate detail. The extreme operation learner may fail successfully to build a conceptual overview and display the learning pathology *improvidence*—to some extent "failing to see the wood for trees."

These constructs are related to the study approaches measured by Entwistle's inventory. Operation learning represents analytic learning consisting of *use of evidence* plus its pathological counterpart—*unrelated memorizing*. Wholist learning is represented by comprehension learning, which consists of *relating ideas* and its pathological counterpart *globetrotting*—essentially overgeneralizing without paying sufficient attention to supporting evidence. Globetrotting has been dropped by later versions of Entwistle's inventory, which to some extent has focused more on the deep/surface distinction than the wholist/analytic.

Pask's constructs have been linked to an arguably more fundamental dimension of human difference, namely *cognitive complexity*, individuals with a wholist bias being more cognitively complex than their analytic counterparts (Pask, 1976b, 1979). Cognitive complexity relates to the degree of differentiation with which an individual views the world. At one extreme, the cognitively simple individual will view the world in dualistic, black/white, right/wrong terms. More cognitively complex individuals, however, will engage in relativistic reasoning in which contrasting views may be equally valid in different circumstances and from different points of view. This construct has been studied in relation to information science (e.g., Ford, 1984, 1986).

Information-Related Research into Individual Differences

Saracevic (1991, p. 85) in his review of research into individual differences relevant to IR concluded that:

> . . . the degree of agreement (expressed by a variety of measures) in human decisions relating to organizing, representing, searching and retrieving of information is relatively low and the range of performance is relatively high . . . it is clear that differences in human decisions have a large im-

> pact, if not THE predominant impact, on how IR systems perform.

A number of studies of information-seeking behavior have included individual differences as variables. Ford, Wood, and Walsh (1994), for example, studied the searching of Silver Platter's CD-ROM-based Library and Information Science Abstracts (LISA). Sixty-seven postgraduate students conducted 275 searches on subjects related to their coursework. They were tested for study approaches and for field-dependent/-independent cognitive style. Their searching strategies were classified in terms of relative breadth (entailing a high use of *OR*, *truncation*, and generic *descriptors*) and narrowness (a high use of *AND*, and *date* or *language qualifiers*). Search effectiveness was measured in terms of *precision*, *recall*, and *number of relevant references retrieved*. Students searched in two experimental conditions: with postings and without. The researchers found that in the "with postings" experimental condition (the normal searching condition for the database), field-independent individuals, and comprehension learners used broader search strategies, operation learners using narrower searches. Versatile learners (i.e., those able to combine wholist comprehension learning with analytic operation learning) outperformed comprehension learners in the number of relevant references retrieved (their expected characteristic *forte*), and outperformed operation learners in relation to search precision (their expected characteristic *forte*).

In a subsequent study (Wood, Ford, Miller, Sobczyk, & Duffin, 1996), 105 undergraduate students carried out online searches of CD-ROM databases for information on topics relating to their coursework. Databases included Inspec, Biological Abstracts, Social Sciences Index, Compendex, ABI-Inform, General Sciences Index, and Modern Languages Association. The students were tested for cognitive styles and study approaches. Search strategies were logged for analysis. Relative to field-independent searchers, field-dependent individuals used fewer new terms, had a higher level of perceived subject knowledge, and reported a higher general use of computer-based information services. Comprehension learners, relative to operation learners, engaged in a greater number of search strategies overall, used more new terms, and a greater range of different terms. They were also more aware of broadening/narrowing search techniques. Field-dependent individuals retrieved more references, and more relevant references. They also reported higher levels of perceived search success. Comprehension learners retrieved more relevant references. Operation learners reported more satisfaction with their search results.

Web-Based Information Seeking

It is also important to conduct information retrieval (IR) research within a Web-based context, as opposed simply to extrapolating from studies in more traditional information contexts, because the users of IR tools on the Web are very different from users of traditional retrieval tools. As Jansen and Pooch (2001, p. 244) note:

> . . . the Web is a unique searching environment that necessitates further and independent study.

A study by Jansen, Spink, and Saracevic (2000), analyzing over 51,000 queries by over 18,000 users, has also drawn attention to this fact, noting a number of differences. Specifically, Web searchers are not at ease with boolean and other advanced search features, make little use of relevance feedback when available, and typically do not scan results beyond the first page or so of hits. This study complements previous research by Jansen, Spink, Bateman, and Saracevic (1998); Jansen et al. (2000); Silverstein, Henzinger, Marais, & Moricz (1999); and Hoelscher (1998).

Wang, Hawk, and Tenopir (2000) reviewed a number of studies of Web searching, concluding that generally users are not very successful, that they experience difficulties with search engine syntax and that some 30% of searches result in zero hits. In contrast, Jansen (2000) reports that generally people are successful in finding what they want on the Web. Spink, Bateman, and Jansen (1999) also note that 70% of their sample reported that they found relevant material, apparently without the need to employ boolean or other advanced techniques. Jansen references a number of studies indicating that although failure rates are high amongst searchers who use advanced techniques, Web searching may be considered to offer quality comparable to that offered by professional reference librarians. Jansen concludes that simple searches are "good enough," and that the value added by successful advanced searching is minimal. In line with a number of other studies, Jansen reports users' low tolerance of long pages of hits, with users rarely browsing more than 10 results.

Fidel et al. (1999) studied navigation patterns and understanding of the nature and structure of the Web among 11th- and 12th-grade schoolchildren. Her study highlighted issues including: the important role played by visual information and the use of "landmarks" in searching navigation, the effects of previous experience, the variance in need for guidance and levels of planfulness displayed by different children, the prevalence of an "assignment oriented" searching approach, and low tolerance of long pages of hits.

A number of Web-specific studies have included individual differences as variables. Wang et al. (2000), for example, investigated cognitive and affective aspects of searching by 24 Masters students. As in the study by Jansen et al. (2000), they found that users often did not scrutinize results much beyond the first screen. They highlight how easily searchers can develop poor mental models, and stress the need for interfaces to respond to—and attempt to enhance—such models. They also found interactions between cognitive style and both difficulty and confusion experienced field-dependent students experiencing more difficulty and confusion than their field-independent counterparts. Levels of anxiety were linked to negative feelings, which in turn could affect levels of persistence in searching.

Lazander, Biemans, and Wopereis (2000) studied the effects of levels of experience on Web searching. Twenty-five preuniversity students performed three tasks each designed to observe their performance in locating Web sites and finding information contained within those Web sites. The first part of each task entailed skills in using a search engine, the second required browsing skills. Students with higher levels of Web experience displayed superior searching performance, requiring less time, producing more correct responses and engaging in fewer actions. In line with the researchers' hypothesis based on previous hypertext research, levels of experience did not affect browsing performance.

Palmquist and Kim (2000) studied the effects of both experience and cognitive style on Web searching. They investigated searching by 48 undergraduate college students of a university Web site when conducting factual and topic searches. Search performance was measured in terms of time required, and the number of nodes traversed, to locate a relevant information item. They found that cognitive style interacted with experience of on-line database searching. Field-dependent novice searchers took longer and traversed more nodes in locating relevant information than field-independent novices. No significant cognitive style differences were found among experienced searchers.

Ratzan (2000), in a study of 350 users, investigated differences in perceptions of the Web in terms of metaphors. This study found that the nature of users' metaphorical images of the Web changed with levels of skill. Metaphors employed by novices were often redolent with confusion, complexity, and frustration. Intangible metaphysical metaphors were used only by experts. There were also gender differences, females reporting more "frontier" and "highway" metaphors, and males more than females rating themselves as highly skilled.

Ford and Miller studied perceptions of 75 undergraduate and postgraduate university students relating to their use of the Internet. They found significant differences according to gender, concluding (1996, p. 188) that:

> The men in this sample seem to enjoy browsing around the Internet, often with no clear plan, happy to plough through irrelevant in the search for personally interesting (as opposed to work-related) material. The women, by comparison, seem relatively disoriented by and disenchanted with the Internet, generally feeling themselves unable to find their way around effectively. They tend to use it for work purposes as opposed to personal interest, to use it only when they have to, and to look at items only when they have been suggested to them (as opposed to browsing around).

Differences were also found for cognitive style and age. Factor analysis linked a verbalizer (as opposed to imager) cognitive style with anxiety about information overload, and a passive approach to Internet use in terms of respondents only using it when required to, and tending only to look at items suggested to them. Age was associated with use of the Internet for work-related as opposed to personal matters, and also with information overload. Correlation analysis identified significant links between an imager cognitive style and being able to keep "on target," avoiding irrelevant material—while at the same time being tolerant of such material—and preferring a well-planned approach to using the Internet. There were correlations also between a wholist cognitive style and: preferences for browsing over keyword searching, and for a broad approach to Internet exploration; and perceptions of often getting sidetracked into irrelevant material. Older respondents felt that the Internet was too unstructured for their liking.

Morahan-Martin (1998) reviews several gender-related studies relating to Internet use, concluding that: gender is a major predictor of internet use and attitudes (Katz & Aspden, 1996; Kraut, Scherlis, Mukhopadhyay, Manning, & Kiesler, 1996); females tend to experience more difficulty finding information online (GVU, 1997a); females feel less competent and comfortable using the Internet (Morahan-Martin & Schumacher, 1997; Schumacher & Morahan-Martin, 1998); males use the Internet more frequently than females, and make use of a greater variety of Internet applications (FIND/SVP, 1997; GVU, 1997a, 1997b, 1998; Morahan-Martin & Schumacher, 1997); and although the gender gap in Internet use has narrowed recently, it seems now to have stabilized somewhat (GVU, 1998; NUA, 1997; Pavlik, 1998).

Theoretical Framework and Research Questions

The research presented here starts from the position that relatively inductive data exploration approaches may usefully complement hypothetico-deductive approaches to the study of human aspects of IR. Inductive approaches can be useful in generating what Olaisen (1991, p. 254) has termed "sensitizing" concepts, which:

> . . . offer a general sense of what is relevant and will allow us to approach flexibility in a shifting, empirical world to "feel out" and "pick one's way in an unknown terrain" . . . In sum, the on-going refinement, formulation, and communication of sensitizing concepts must inevitably be the building block of our exploratory theory.

The present research adopted a data exploration, rather than hypothesis testing, approach in that it sought to discover, via broad-based data exploration using factor and regression analyses, sensitizing concepts in the form of statistically based relationships between individual difference factors and retrieval effectiveness.

The nature of evidence sought falls within the positivist tradition. Although many of the constructs being studied are essentially social, including attitudes and perceptions, the nature of evidence sought was statistical. A psychometric measure was used to obtain cognitive style data, and Likert scales used to quantify attitudes and perceptions. The limitations of positivist approaches to human issues are ac-

knowledged. However, we feel that it is useful where possible to obtain baseline data enabling the strength of evidence to be measured quantitatively. Such evidence by no means invalidates—indeed arguably provide a more solid base for—complementary illuminative investigation of the same and related issues (Ford, 2000).

Such exploratory research still requires a focus and guiding theoretical framework. In his review of research findings from the field of human individual differences relevant to IR, Saracevic (1991, p. 85) notes that we need to link general findings specifically to IR—and to link IR findings back into more general theory:

> We are still lacking a theoretical framework and/or explanation for all these findings. Without such a framework, the work on individual differences in IR will continue to proceed as in the past, using a shotgun approach.

Adopting a more atomistic focus, Jansen and Pooch (2001) also stress the need for an agreed framework for IR research—particularly in relation to Web-based research. Their recommendations for terminology relating for example to *searches*, *queries* (*initial*, *repeat*, and *modified*), *terms*, and *term modifiers*, and for the inclusion in statistical analyses of baseline data including means and standard deviations for these elements, as well as specification of *search options* available at the time of experiments, etc., have where applicable been adopted in the present study.

In terms of theoretical content, the present study was based to a large extent on Wilson's model of information behavior (Wilson & Walsh, 1996). The particular focus of information seeking behavior that the study sought to illuminate were the effects on retrieval of individual user characteristics. These were demographic (gender and age), cognitive, and affective (including aspects of anxiety and self-efficacy).

Although these aspects can be accommodated in models such as those of Ingwersen (1996) and Saracevic (1996), they are included specifically in Wilson's model. In other words, there is a better match of focus and granularity between this model and the concerns of the research presented here. Other models focus in some depth on aspects of less concern to the present research—for example, stages of information seeking (Kuhlthau, 1991, 1994); behavioral elements (Ellis, 1989; Ellis & Haugan, 1997); the integration of stages and elements (Wilson, 1999); the nature of interactions over time (Spink, 1997); states and the shifts between them to bridge meaning gaps (Dervin, 1992); and levels of uncertainty (Wilson, 1999); complex conceptions of the notion of "relevance" (Spink, Greisdorf, & Bateman, 1998); and users' mental models of the "Web space" (Wang et al., 2000).

On the basis of individual difference research relating not only to IR but also other areas of human activity (e.g., Ford, 1999a, 2000) the factors selected for study arguably are potentially important building blocks in models of human information seeking relevant to system design.

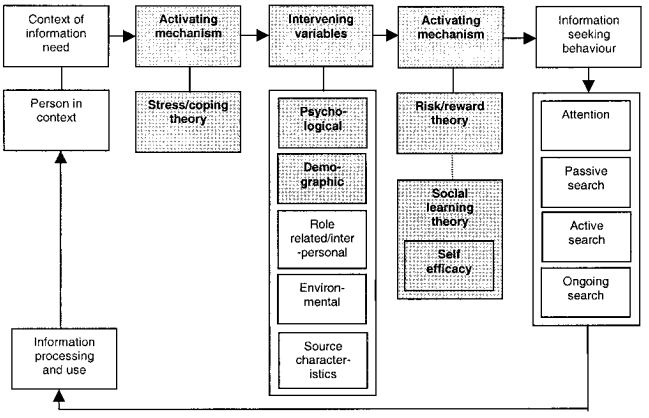

FIG. 1. Wilson's model of information behavior (Wilson & Walsh, 1996).

The research reported here is not centrally concerned with IR strategies. Although retrieval performance and human individual differences must be mediated by retrieval strategies, the research sought to discover whether there might be any *direct* links between these differences and performance—without reference to strategies. The study utilized a simple binary conception of "relevance"—deliberately so to establish a clear baseline arguably facilitating the exploration of the effects of individual difference factors. Wilson's model again is particularly suited to the focus of the research, because it elaborates neither the notion of relevance nor that of strategies, preferring a "hold all" box labeled "information processing and use," and three general "search" boxes relating to passive, active, and ongoing searching. The match between Wilson's model and the present research is shown in Figure 1, in which those constructs that form the focus of the research are shaded.

The research sought to discover whether there is any statistically based evidence that retrieval effectiveness is affected by the following components of Wilson's model:

(1) Activating mechanism—stress/coping theory: reflected by inclusion of *fear of failure* and *time management* variables.
(2) Activating mechanism—risk/reward theory and social learning theory: reflected by inclusion of a range of Internet perceptions relating to self-efficacy, and study approaches reflecting intrinsic (deep) and extrinsic (surface) reward motivation.
(3) Intervening variables: including: (a) psychological differences between individuals, consisting of: (i) cognitive (cognitive styles and levels of experience); (ii) affective (Internet and study attitudes and perceptions); (b) demographic differences (age and gender).

Method

Participants

The sample consisted of volunteers drawn from two cohorts (1999 and 2000 entry) of three taught Masters'

programs at the Department of Information Studies, University of Sheffield. These programs are: the MA in Librarianship, the MSc in Information Management, and the MSc in Information Systems. All students on each of these programs were invited to participate in the study. The two cohorts consisted of 250 students.

Data Collection Instruments

Individual Differences

A 63-item questionnaire was devised that included the scales described below. Responses were scored using a five-point Likert scale. Items relating to Internet perceptions, levels of experience and cognitive complexity are reproduced in full in the Appendix. Illustrative examples of each of the subscales used from Entwistle's (Tait & Entwistle, 1995) lengthy *Revised Inventory of Approaches to Studying* also appear in the Appendix. Individual differences were measured as follows:

(1) Approaches to studying were measured using 32 items from Entwistle's *Revised Approaches to Study Inventory*. Items relating to deep, surface, and strategic approaches were used.
(2) Internet perceptions were measured using Ford and Miller's (1996) 12-item questionnaire.
(3) Levels of experience of using a Web search engine, of using AltaVista specifically, and of boolean searching, were measured by three items devised for the present study.
(3) Cognitive complexity was measured by four items devised for this study. Standardized tests of cognitive complexity can be complex to administer and interpret. Therefore, a measure that was relatively quick and easy to administer and interpret (but by the same token partial and limited compared to such standardized tests) was devised. This measure relied on participants' own perceptions of the extent to which they engage in relativistic as opposed to dualistic thinking.

Riding's (1991) *Cognitive Styles Analysis* was used to measure participants' cognitive styles—specifically, wholist/analytic, and verbalizer/imager dimensions. This instrument offers computerized administration and scoring. Its wholist/analytic test consists of two subtests. In the first, subjects are required to judge the similarity of a series of complex geometrical figures—a task requiring field-*dependent* capacity. The second subtest requires subjects to determine whether a simple shape is contained within a more complex geometrical figure—a task requiring the disembedding capacity associated with field-*independence*. In this way, field-dependent competence is positively measured rather than being inferred from poor field-independent capability. The verbal/visual measure presents the user with a series of statements about the relationship between two words, and asks him/her to decide whether each statement is true or false. Half the statements concern conceptual relationships (asking if A is a type of B): the other half concern visual relationships (asking if A is the same color as B). Shorter correct response times will be displayed by verbalizers in the case of the conceptual similarities (because these are essentially verbal and cannot be represented visually). Imagers are likely to give accurate responses more quickly to the statements concerning visual relationships (because retrieval from mental images would be quicker).

Details of age and gender were obtained via a form on the opening screen of the Web-based search interface (described below).

Search Data

A JavaScript front-end was built that interfaced with the AltaVista search engine. AltaVista was selected because it offers boolean and best-match searching—two key generic search mechanisms—and because it offers relatively broad coverage of the Web. Searchers were free to choose the simple search option, which provides best match searching, and/or the advanced search option, which offers both best match and boolean. These can be used alone or in combination. In the latter case, the boolean search restricts the hit list of retrieved items to those matching the searcher's boolean specification, ordering them according to terms entered in the best match search box. "Best match" searching is hereafter referred to as "keyword" searching.

The JavaScript front-end recorded all search data submitted to the search engine, which were automatically sent to the researchers.

The task that the participants were asked to complete in this part of the project was as follows:

> A technician cuts his finger badly in the Information Studies Departmental office. What are the legal implications of this for the university? Find relevant information on the Web.

The search topic was intended to require searchers to generate search terms other than those contained in the topic as given—for example, more general search terms such as "health and safety." Searching was conducted using Netscape Navigator version 4.

As stated in the Introduction section, an important objective of the present study was to investigate the effects of relatively fundamental and enduring factors—as opposed to the characteristics of particular searching systems. The use of one search engine would seem to run counter to this objective. However, the independent variables used in the investigation themselves represent what might be considered relatively fundamental and enduring factors—namely, cognitive styles, study approaches, Internet perceptions, age, and gender. The purpose of the present exploratory study was to seek to discover any effects of these factors on information seeking, using in the first instance a particular search engine, and a particular search topic. The necessity for further investigations of any such differences where found, using a variety of search engines and search topics, is acknowledged.

TABLE 1. Phenomena studied, their associated variables and measuring instruments.

Phenomena studied	Variables	Measuring instruments
APPROACHES TO STUDYING		
Deep learning	1. Intention to understand	Entwistle's *Inventory of Approaches to Studying* (see Appendix)
	2. Active interest	
	3. Relating ideas	
	4. Use of evidence	
Surface learning	5. Intention to reproduce	
	6. Passive learning	
	7. Unrelated memorizing	
	8. Fear of failure	
Strategic approach	9. Intention to excel	
	10. Effective time management	
INTERNET PERCEPTIONS	11–22. Twelve items measured perceptions to various aspects of the Internet use (reproduced in the Appendix).	Ford and Miller's *Internet Perceptions Questionnaire* (see Appendix)
LEVELS OF EXPERIENCE	23. Experience of using a Web search engine	
	24. Experience of using the Alta Vista search engine	Questionnaire (see Appendix)
	25. Experience of boolean searching	
COGNITIVE STYLE	26. Wholist/analytic bias	Riding's *Cognitive Styles* Analysis
	27. Verbalizer/imager bias	
	28. Cognitive complexity	Questionnaire
AGE AND GENDER	29. Male/female	Riding's *Cognitive Styles* Analysis
	30. Age	
SEARCHING	31. Relevance	Examination of retrieved items

Relevance

Based on the recorded queries (and successive modifications) submitted to the search engine by the participants, searches were resubmitted shortly afterwards by the researcher and printed out. (This, and other limitations of the "relevance" measure are explored in the Discussion section). The first two screens of retrieved items resulting from *each successive query* were then categorized using a simple dichotomous "relevant/not relevant" classification.

A given set of retrieved items was classed as "relevant" if it included material that illustrated the legal implications for an employer of injury at work. The specified search required information about the legal implications of a work injury for an employer. Therefore, sites that looked at work injury from the perspective of the *employee* were not deemed relevant, but sites that examined health and safety laws/regulations were considered relevant.

A single relevance estimate was then calculated in relation to each participant's search across all queries. This was done by dividing the number of queries resulting in the retrieval of one or more relevant items by the total number of queries. Thus, a participant who submitted four queries (changing some aspect of it each time), with only the final modification of the query succeeding in retrieving a relevant item, would receive a relevance score of 0.25.

Variables

Table 1 shows the 31 variables used in this experiment. Variables are shown in the center column. They are qualified where applicable in the left column by the broader category of phenomenon that they represent. Thus, for example, approaches to studying consist of three subscales: deep learning, surface learning, and strategic approach. Deep learning consists of four variables. As shown in the column to the right, these variables are measured using the *Revised Inventory of Approaches to Studying*.

Procedure

Participants completed the "individual differences" questionnaire before taking the cognitive styles test. The requirements of the experiment were described, and participants were then asked to carry out the search. They were not constrained in terms of the number of queries they could submit. Nor was any time limit imposed on the searching. Each successive query was recorded separately.

Data Analysis

Multiple regression and factor analysis were applied to the data, using SPSS version 9. The nature of, and rationale for employing these different techniques are described below. A level of statistical significance of $p < .05$ was adopted for the study.

Factor Analyses

Factor analysis identifies clusters of variables that share some underlying relationship. Unlike regression (described below), it does not calculate levels of statistical significance. Factor loadings indicate the correlation between each vari-

TABLE 2. Gender distribution for the sample and the population sampled.

	Male	Female	Total
MA Librarianship:			
population	21 (25.6%)	61 (74.4%)	82 (100%)
sample	8 (25%)	24 (75%)	32 (100%)
MSc Information Management:			
population	46 (46.5%)	53 (53.5%)	99 (100%)
sample	8 (30.8%)	18 (69.2%)	26 (100%)
MSc Information Systems:			
population	50 (72.5%)	19 (27.5%)	69 (100%)
sample	4 (66.7%)	2 (33.3%)	6 (100%)
Total population	117 (46.8%)	133 (53.2%)	250 (100%)
sample	20 (31.25%)	44 (68.75%)	64 (100%)

able and the underlying relationship used to cluster it together with other variables. Factor analysis can be particularly useful in identifying relationships not revealed by simple bivariate correlation or linear regression.

In the present study, factor analysis was used to identify the extent to which different sets of variables clustered around different levels of retrieval effectiveness, as measured by relevance scores. Four factor analyses were conducted on the following sets of variables: (1) relevance and approaches to studying; (2) relevance and Internet perceptions; (3) relevance and levels of experience; and (4) relevance and age, gender, and cognitive style.

Four distinct analyses (as opposed to a single analysis using all variables) were considered for both conceptual and procedural reasons. Each of the four sets of variables represented a broad class of conceptually linked factors potentially affecting searching. Separating them prevented the potential dilution of relationships linked to relevance which might have resulted from the combination of disparate groups of variables, and also allowed comparison between these groups. From a procedural point of view, it is important to note that the number of variables input to any one factor analysis should not exceed one-fifth of the sample number (Coakes & Steed, 1999). Combining sets would in several cases have resulted in an excessive number of variables being entered into the analysis. Two factors were sought in each analysis, principal component analysis being employed as the extraction method.

Multiple Regression

Regression enables the identification of statistically significant relations between multiple variables. Specifically, it enables identification of the effect of several independent variables on a dependent variable—i.e., the extent to which variations in the dependent variable can be predicted by variations in the independent variables. In the present study, this was used to measure the effects of the various "individual difference" variables on retrieval effectiveness.

When a backwards entering procedure is used (as in the present study), variables contributing least to the prediction are progressively removed until a best-fitting model is established. The statistical significance of the model as a whole and of each contributing variable within it is calculated, as is the extent to which the model accounts for all the variation in the dependent variable. The regression analysis was performed using the combined sets of variables. The backwards entering method resulted in an acceptable number of variables appearing in the final model. This analysis also identified which, of all the input variables, had a significant linear effect on retrieval effectiveness. Interactions between independent variables are taken into account in the calculation of significance levels.

Because the residuals relating to the dependent variable were not normally distributed, a new dichotomous variable was created for relevance. Each category of the new variable exceeded 20% of the cases—thus fulfilling requirements for suitability for regression analysis (Hedderson, 1991). Independent variables consisted of: cognitive styles, study approaches, Internet perceptions, experience, age, and gender.

Results

The Population

Sixty-nine postgraduate students volunteered to participate in the experiment. Information on degree program was missing for four students, and data on gender and searching for one student. The latter student was excluded from the analysis. Table 2 shows the gender distribution by program for (a) the sample of 64 for whom gender and program information was available, and (b) the population from which the sample was drawn. Percentages relate to gender. This sample consisted of 20 (31.25%) males, and 44 (68.75%) females. As can be seen from Table 2, the sample was broadly representative, in terms of gender, of the population sampled. The greatest discrepancy in male/female balance between population and sample was 15.7% for the MSc in Information Management. That for the MA in Librarianship was 0.6%, that for the MSc in Information Systems 5.8%. There was an overall discrepancy of 15.55%.

Mean scores for levels of experience of (a) using search engines, (b) using AltaVista specifically, and (c) boolean

TABLE 3. Levels of experience of the sample (N = 66).

Experience of. . .	Using search engines	Using AltaVista	Boolean searching
Mean (on a 1–5 scale)	3.30	2.76	2.58
Std. deviation	1.01	1.14	1.25

searching, are shown in Table 3. Full data on all three experience variables were available for 66 students. Whereas all respondents had some experience of search engines, 6 (8.7%) reported no experience of using AltaVista, and 14 (20.3%) had not engaged in boolean searching.

The Searches

As noted above, search data was missing for one student, leaving valid data for 68 students. The total number of queries conducted by these students (i.e., the initial and modified queries submitted to the search engine) was 228 (mean 3.35, SD 2.37, minimum 1 and maximum 13). Of the 228 queries, 99 were boolean only (mean 1.46, SD 1.65, minimum 0 and maximum 6), 86 keyword only—as noted above, the term "keyword" is preferred to "best match"—(mean 1.26, SD 1.47, minimum 0 and maximum 7), and 43 combined—i.e., terms were put in both boolean and keyword boxes using AltaVista's *advanced search* option—(mean 0.63, SD 1.13, minimum 0, and maximum 5). Table 4 shows the frequency of queries for the search. Table 5 shows the frequency of terms in boolean and keyword queries.

Table 6 gives further basic data for (a) the sample as a whole and (b) males and females separately. Gender differences were significant (t-test) only in the case of the number of terms per query in "keyword only" queries, males using more terms than females (t =. −2.219; p = .030).

Factor Analyses

The results of the four factor analyses are presented in Tables 7–9. Factor loadings of less than .2 are omitted from the tables.

TABLE 4. The frequency of queries (N = 228) for the search.

1 query: 16 (23.5%)
2 queries: 15 (22.1%)
3 queries: 13 (19.1%)
4 queries: 7 (10.3%)
5 queries: 4 (5.9%)
6 queries: 4 (5.9%)
7 queries: 6 (8.8%)
8 queries: 2 (2.9%)
13 queries: 1 (1.5%)

TABLE 5. The frequency of terms in boolean and keyword queries.

Boolean queries (N = 142*)	Keyword queries (N = 129**)
1 term: 4 (2.8%)	1 term: 7 (5.6%)
2 terms: 27 (18.6%)	2 terms: 20 (16.1%)
3 terms: 44 (30.3%)	3 terms: 23 (18.5%)
4 terms: 29 (20%)	4 terms: 18 (14.5%)
5 terms: 17 (11.7%)	5 terms: 23 (18.5%)
6 terms: 14 (9.7%)	6 terms: 14 (11.3%)
7 terms: 3 (2.1%)	7 terms: 5 (4.0%)
8 terms: 4 (2.8%)	8 terms: 5 (4.0%)
9 terms: 3 (2.1%)	9 terms: 5 (4.0%)
	10 terms: 3 (2.4%)
	11 terms: 1 (0.8%)

*Number includes all Boolean queries (including combined queries in which searchers used both boolean and keyword boxes).

**Number includes all keyword queries (including combined queries in which searchers used both boolean and keyword boxes).

Approaches to Studying

This section presents the results of the subjects' responses to Entwistle's *Revised Inventory of Approaches to Studying* (see Appendix). Table 7 shows loadings on this measure and on relevance. The cumulative variances of the two principal components were 32.147% and 45.323%. Initial Eigenvalues were 3.536 and 1.449.

Of particular interest are the loadings in the second component linking low relevance with poor time management and fear of failure. While avoidance of a surface approach to learning (passive learning; intention to reproduce as opposed to understand; and unrelated memorizing), intention to excel and use of evidence distinguished factor 2 from factor 1, a deep approach to learning (active interest; intention to understand; and relating ideas) failed to differentiate the two factors.

Internet Perceptions

This section presents the results of the subjects' responses to Ford and Miller's *Internet Perceptions Questionnaire* (see Appendix). Table 8 shows loadings on this measure and on relevance. The cumulative variances of principal components 1 and 2 were 26.125% and 38.440%. Initial Eigenvalues were 3.396 and 1.601.

The first component again loads on low relevance (though not particularly highly), linking it with perceptions of not finding one's way around, getting lost, a lack of control, and feelings that the Internet is too unstructured. It is also linked with an apparently passive approach (respondents only looking at things suggested to them). Component 1 is also distinguished by low ratings given to visual as opposed to verbal aspects of the Web, and to a preference for breadth as opposed to depth when learning about the Internet.

Cognitive Style, Age, and Gender

This section presents the results of the subjects' responses to Riding's *Cognitive Styles Analysis*. Table 9

TABLE 6. Search parameters for the whole sample and grouped by gender (N = 68: female = 46; male = 22).

Variable	Mean (SD)	Group means (SD)	
Boolean only searches	1.46 (1.65)	Female	1.57 (1.64)
		Male	1.23 (1.69)
Keyword only searches	1.26 (1.47)	Female	1.28 (1.56)
		Male	1.23 (1.31)
Combined searches	0.63 (1.13)	Female	0.63 (1.18)
		Male	0.64 (1.05)
Queries per search	3.35 (2.37)	Female	3.48 (2.53)
		Male	3.09 (2.02)
Terms per query (boolean)	2.2525 (1.8360)	Female	2.1885 (1.7953)
		Male	2.3864 (1.9545)
Terms per query (keyword)	2.4501 (2.3723)	Female	2.0211 (2.1239)
		Male	3.3473 (2.6539)
ANDs (boolean only)	0.8997 (0.9164)	Female	0.8854 (0.8287)
		Male	0.9295 (1.0985)
Ors (boolean only)	0.4582 (1.2531)	Female	0.5507 (1.4771)
		Male	0.2650 (0.5262)
AND NOTs (boolean only)	4.912E-02 (0.1439)	Female	4.870E-02 (0.1474)
		Male	5.000E-02 (0.1395)
NEARs (boolean only)	9.044E-02 (0.3383)	Female	0.1300 (0.4061)
		Male	7.727E-03 (3.624E-02)
Phrase searching (Boolean)	0.2512 (0.5931)	Female	0.1830 (0.4372)
		Male	0.3936 (0.8255)
Phrase searching (keyword)	5.574E-02 (0.2024)	Female	7.696E-02 (0.2414)
		Male	1.136E-02 (5.330E-02)
Use of brackets (boolean only)	0.3096 (0.6045)	Female	0.2737 (0.5888)
		Male	0.3845 (0.6434)
Use of upper case (boolean)	0.2190 (0.5286)	Female	0.2259 (0.5127)
		Male	0.2045 (0.5727)
Phrase upper case (keyword)	0.2446 (0.7723)	Female	0.1143 (0.2932)
		Male	0.5168 (1.2665)
Use of limiters (boolean—not used in keyword)	4.294E-02 (0.1567)	Female	2.696E-02 (0.1283)
		Male	7.636E-02 (0.2034)
"Help" accesses	0.2454 (0.3662)	Female	0.2579 (0.3310)
		Male	0.2253 (0.4281)
Spelling errors (boolean)	2.559E-01 (0.1132)	Female	0.0000 (0.0000)
		Male	7.909E-02 (0.1910)
Spelling errors (keyword)	5.265E-02 (0.2115)	Female	1.261E-02 (6.273E-02)
		Male	0.1364 (0.3513)

shows loadings on this measure and on relevance. The cumulative variances of the principal components were 27.431% and 48.652%. Initial Eigenvalues were 1.646 and 1.273.

TABLE 7. Results of the factor analysis for relevance and study approaches (measured using the *Revised Inventory of Approaches to Studying*).

	Components	
	1	2
Relevance		−472
Fear of failure	−468	643
Effective time management		−398
Intention to excel	572	
Passive learning	−798	
Intention to reproduce	−568	
Unrelated memorizing	−639	
Active interest	237	471
Intention to understand	721	259
Use of evidence	791	
Relating ideas	627	554

In this analysis high and low relevance loaded on separate components. High relevance is linked to age, low cognitive complexity, and male gender. Low relevance is linked to a verbalizer (as opposed to imager) cognitive style and to high cognitive complexity.

Experience

Experience loaded separately from relevance, not indicating any relationship between levels of relevance and the three experience variables.

Multiple Regression

Input to the multiple regression consisted of data relating to cognitive styles, study approaches, Internet perceptions, age, and gender. As shown in Table 10, the best-fitting most statistically significant model accounted for 20% of the variance in relevance (14.6% when the R square was adjusted). Retrieval effectiveness (as measured by relevance scores) could be predicted to a statistically significant level

TABLE 8. Results of the factor analysis for relevance and Internet perceptions (measured using the *Internet Perceptions Questionnaire*).

	Components	
	1	2
Relevance	−.225	
I usually only look at things on the Internet that have been suggested to me.	562	
Despite its complexity, I generally manage to find my way around the Internet fairly effectively.	−817	242
I rarely find anything useful on the Internet.	726	286
I usually manage to keep 'on target' and avoid too much irrelevant material when using the Internet.	−563	314
I'm prepared to plough through quite a lot of irrelevant information in case there's something useful I might otherwise miss on the Internet.	−590	−480
If I had to choose only one, I'd prefer keyword searching to browsing (hypertext) on the Internet.		584
The Internet is too unstructured for my liking.	452	
I personally think that the graphical elements of the World Wide Web (i.e., pictures, icons, graphics, etc., as opposed to just text) make me much more likely to use the Internet than if it were just text based.	−253	
When I use the Internet, I feel as though I'm not as "in control" as I would like.	568	
My advice to someone like myself would be: the best way to learn to use the Internet is to explore everything broadly to get a comparative "feel" of the various aspects/tools before getting down to mastering any one in depth.	−483	
I tend to get lost when using the Internet.	473	−393
It's best to use the Internet only when you have a well defined plan (rather than just browsing around).	346	698

by a gender ($p = .018$), and by feelings of being on target ($p = .047$) and in control ($p = .047$) and when using the Internet. The model as a whole was a significant predictor at a level of $p = .010$. The perception that the Internet is too unstructured, although not on its own a significant predictor, contributed to the model. However, the direction of the relationship between this variable and successful retrieval it not consistent between the regression and the factor analysis. High levels of retrieval effectiveness were linked to *agreement* that the Internet is too unstructured in the factor analysis, but with *disagreement* in the regression. The reasons for this discrepancy are not clear.

Discussion

Relationship between the Different Analyses

A number of relationships were identified using factor analysis that multiple regression did not subsequently identify as statistically significant. However, it must be remembered that the regression is a different type of analysis, aiming to identify a particular type of relationship. Specifically, multiple regression seeks to predict the values of a dependent variable (in this case, relevance) from the values of several independent variables (cognitive styles, study approaches Internet perceptions, age, and gender).

Also, regression identifies only *linear* relationships. It is possible for two variables to be related while not being significantly correlated linearly with each other. For example (as is the case in the analysis reported here), low scores on one variable may be significantly correlated with low scores on another, while *high* scores on both may *not* be correlated. Factor analysis is capable of identifying such a relationship, via factor loadings linking only negative values of the variables. The relationship between high scores on the two variables may be more complex, entailing other interacting factors. Factor analysis is, therefore, particularly useful in exploratory analyses seeking to identify interesting relationships worthy of further investigation. It is also important to note that, due to the data characteristics required

TABLE 9. Results of the factor analysis for relevance, age, gender, and cognitive style (measured using the *Cognitive Styles Analysis*).

	Components	
	1	2
Relevance	.393	−.468
Age*	.750	
Analytic cognitive style	.415	.603
Imager cognitive style		.680
Cognitive complexity	−.297	.449
Male gender*	.815	

*Using Spearman's rho, male gender and age were significantly correlated (correlation .339, $p = .004$), and male gender and analytic cognitive style are significantly correlated (correlation .251, $p = .037$). The implications of these correlations are elaborated in the Discussion section.

TABLE 10. Linear regression results for the effects on relevance of approaches to studying, Internet perceptions, cognitive styles, age, and gender.

Significance of the model $p = 0.010$. R square .201 (adjusted R square .146). Condition index (dimension 5) 13.838	t	sig
Constant	−.340	.735
Gender	2.434	.018
I usually manage to keep "on target" and avoid too much irrelevant material when using the Internet.	2.031	.047
The Internet is too unstructured for my liking.	1.733	.088
When I use the Internet, I feel as though I'm not as "in control" as I would like.	−2.031	.047

for the analysis, the dichotomous measure of relevance used for the regression was cruder than that used in the factor analyses. It thus seems reasonable to conclude that, far from being disproved by their lack of confirmation in the regression analysis, the relationships identified in the factor analyses are worthy of further investigation.

The Emerging Picture

It is interesting that the mean numbers of terms per query, across both keyword and boolean queries, are close to those reported for much larger and heterogeneous groups. Xu (1999), based on available studies of Web searching, notes that average query lengths rose from 1.5 terms in 1996 to 2.6 terms in 1999. Spink, Wolfram, Jansen, and Saracevic (2001) report means based on a sample of 1,025,910 Excite queries. The mean numbers of terms per query for the present sample across both boolean and keyword queries were between 2.1885 and 2.3864 *except* in the case of keyword queries submitted by males, with a mean of 3.3473. As previously noted, this difference was statistically significant.

Xu also noted that use of boolean operators also rose from 22% in 1996 to 29% in 1999. Spink, Wolfram, Jansen, and Saracevic, however, note that less than 5% of all queries in their sample used boolean term modifiers. In the present study, 99 of the 226 queries (43.8%) were boolean. The fact that this percentage is much higher is not particularly surprising because the sample consisted entirely of Masters students enrolled on courses in which the teaching of boolean searching was an important component. In this context, it is arguably more interesting that the number of terms per query used by this sample was so similar to that characterizing the samples drawn from the wider public reported by Xu, and by Spink, Wolfram, Jansen, and Saracevic.

The factor and multiple regression analyses paint an interesting picture. The factor analyses suggest that retrieval *effectiveness* is associated with older individuals, with males, and with relatively low levels of cognitive complexity—but not with levels of previous searching experience. Age correlates significantly with gender—thus confounding the relationship between relevance and these two variables. However, the regression analysis (summarized below) indicates that gender (and not age) is a significant predictor of relevance.

Poor retrieval performance seems linked to a verbalizer cognitive style and to relatively high levels of cognitive complexity. It is also linked to fear of failure and poor time management—despite the adoption by both successful and less successful searchers of a relatively deep study approach (active interest, intention to understand, and use of evidence). It is also related to a range of perceptions of the Internet, including feelings that the Internet is too unstructured, of not being in control, failing to keep on target, failing to find one's way around and getting lost. Links between poor retrieval and a verbalizer as opposed to imager cognitive style are echoed by the factor analysis of Internet perceptions that reveals a relatively low rating, given by those retrieving poorly, to the value of graphic elements of the Web.

The multiple regression analysis indicates that retrieval failure was significantly associated with females, and with feelings of a not being in control, and of being unable to keep on target (avoiding irrelevant material). Conversely, retrieval success was significantly linked to males, and to confidence of being in control and able to keep on target when using the Internet. The regression analysis identifies the most statistically significant predictors of retrieval success and failure. The factor analyses extend this picture by suggesting a range of other variables associated particularly with retrieval failure—linked in not necessarily linear relationships. However, a coherent picture does emerge across the two types of analysis.

Self-Efficacy and Gender

The findings are to some extent in accord with Bandura's social learning theory. This links poor performance less directly with anxiety and low levels of experience than with a blend of these two variables in the form of "self-efficacy" (Bandura, 1977, 1986; Schunk, 1981)—a proposition supported by studies into computer anxiety (e.g., Meier, 1985) and experience (e.g., McInerney, McInerney, & Sinclair, 1994). Self-efficacy, according to Bandura (1986, p. 391) is concerned "not with the skills one has but with judgements of what one can do with whatever skills one possesses."

A number of those variables found in the present study to be linked with retrieval failure may be classified as examples of low self-efficacy. The regression analysis links retrieval failure with students' perceptions of themselves as being unable to maintain control and keep on target. The factor analyses also link failure with perceptions of: a lack of control; and inability to find one's way around, keep on target, and avoid getting lost. They also associate failure with students' more generalized negative perceptions of their study efficacy namely, fear that they are risking failure, and feeling that they are unable to manage their time effectively.

The present study supports the self-efficacy theory in that poor retrieval performance is linked to a cluster of variables characterized as indicating low self-efficacy. Furthermore, it found a *direct* link between poor performance and anxiety (as measured by *fear of failure*). A recent study by Lazander, Biemans, and Wopereis (2000) also found a direct link between performance locating Web sites using a search engine and levels of experience.

The study found links between (a) female gender and poor retrieval performance, and (b) low self-efficacy and poor retrieval performance—but no link between female gender and low self-efficacy, except for a significant correlation between females and disagreement with the item:

> I usually manage to keep "on target" and avoid too much irrelevant material when using the Internet.

There is some evidence for this "missing link" in a study by Ford and Miller (1996). Using correlation and factor analysis, they found links between gender and a range of perceptions of the Internet. Females reported being unable to find their way effectively around the Internet, getting lost, not being in control, and only looking at things suggested to them. All of these features were linked in the present study (as were females) with retrieval failure.

The findings are generally in accord with other related work. For example, Nahl (1993, 1995, 1996) has found evidence that individuals displaying high levels of self-efficacy outperform those with lower levels in relation to a range of factors including search efficiency, success and satisfaction. She notes (Nahl, 1996) that:

> . . . novices who expected to be successful at a search task are more efficient and adaptive searchers than those who express doubt and a lack of self-confidence in their ability to carry out successful searches.

The negative side of this position is stated by Compeau and Higgins (1995, p. 192), who note that:

> Individuals with a weak sense of self-efficacy will be frustrated more easily by obstacles to their performance and will respond by lowering their perceptions of their capability.

Nahl (1996) offers some insight into what she terms "the psychological dynamics of successful Internet learners." Based on a study of self-efficacy in relation to learning Internet skills over a period of 8 weeks (including but not restricted to searching) she notes that:

> . . . it is normal for successful Internet learners to experience increased difficulty and negative emotions for the first few weeks, until the challenging peak, after which the trend reverses. For successful learners, the value and satisfaction ratings remain uniformly positive, even during highest difficulty and uncertainty. At the same time, self-efficacy judgements start and remain positive throughout the training experience.

In relation to gender differences, Brosnan (1998, p. 226) notes:

> One similarity between the computer anxiety and self-efficacy research is an apparent gender difference in both areas. A variety of researchers report gender differences in computer anxiety with females reporting higher levels of computer anxiety than males . . . Gender differences have also been reported in self-efficacy . . . with females reporting less computer-related confidence than males.

He goes on to surmize that this may at least partly due to the findings that vicarious experience (i.e., watching or being told by others) can lower self-efficacy in females (Rosen, Sears, & Weal, 1987) and that females may often receive less verbal encouragement during computer-related learning (Culley, 1988). It may be reasonable to expect that the latter situation may have changed in the 13 years since the study by Culley.

In terms of gender and negative perceptions and use of the Internet more generally, the results are in accord with the studies reviewed by Morahan-Martin (1998), reported in the *Background* section of this article, in which gender emerged as a major predictor of Internet use and attitudes; females tended to experience more difficulty finding information on-line, to feel less competent and comfortable using the Internet, to use the Internet less frequently than males, and to make use of a less varied set of Internet applications.

However, although in line with previous literature into gender differences, the results do seem counterintuitive in the present context in that all the participants were academically highly successful, and experienced in relation to information technology (IT). IT, and information seeking in particular, form a central component of the Masters courses on which they were enrolled. It may be, however, that even high-achieving females now studying IT may be encumbered by the effects of biased training and education in their primary and secondary education of some years ago.

Cognitive Styles

The present study found links between poor retrieval and a verbalizer cognitive style. There were also links between a bias to the verbal, in the form of low agreement with the statement:

> . . . the graphical elements of the World Wide Web (i.e. pictures, icons, graphics, etc. as opposed to just text) make me much more likely to use the Internet than if it were just text-based.

And: poor retrieval; failing to find one's way effectively around the Internet, to keep on target, and to be in control; getting lost; and only looking at things suggested.

These links echo those found in the study by Ford and Miller (1996) between a verbalizer cognitive style and a range of perceptions of the Internet including: only using the Internet when required to do so; only looking at things suggested; not being able to keep on target; not enjoying using the Internet; and feeling anxiety about information overload. Although not identical, arguably the two sets of items reflect similarly negative perceptions experienced by individuals with a verbal as opposed to visual bias.

The finding of links between a verbalizer cognitive style and poor retrieval is to some extent counterintuitive in that information seeking would seem to be essentially a verbal activity, entailing the effective construction, and subsequent reformulations, of verbal search queries. Also counterintuitive are the findings of links between poor retrieval and high levels of cognitive complexity. One would imagine that the ability effectively to generate different query formulations and reformulations to "home in" on relevant items—partic-

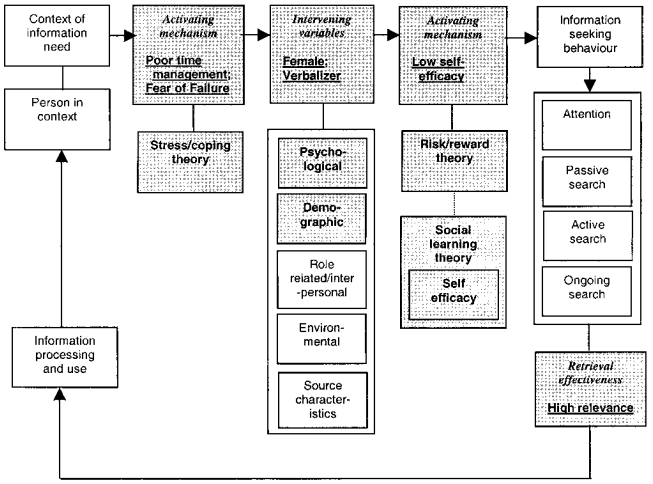

FIG. 2. Partial instantiation of Wilson's model of information behavior (Wilson & Walsh, 1996).

ularly when faced with unsuccessful retrieval—would benefit from the ability to adopt different perspectives and come at a problem from different angles. Verbalizer/imager cognitive style differences and cognitive complexity have not been the subject of much research relating to Internet use or information seeking more generally. Further studies would seem to be desirable.

The present research found no significant links between retrieval effectiveness and wholist/analytic cognitive styles. This negative finding runs counter to previous studies reported in the *Background* section, in which links were found between this dimension of style and computer-based information seeking. Nor did the study find any links between retrieval performance and factors that may, on the basis of previous research, reasonably be expected to differentiate levels of academic performance generally, namely a deep versatile approach to learning (active as opposed to passive learning; intention to understand as opposed to intention to reproduce; relating ideas; and using evidence). Variance in these variables failed to differentiate levels of retrieval success. Clearly, further research is needed to clarify this and the other issues described above.

Implications for Wilson's Model of Information-Seeking Behavior

The research results presented here support those parts of Wilson's model of information-seeking behavior (Wilson & Walsh, 1996) to which they relate in that statistical evidence has been found of the effects on information seeking of activating mechanisms relating to stress/coping theory and to self-efficacy, and of psychological and demographic intervening variables. Furthermore, the results extend the model in terms of (a) instantiating the general model with specific cases, and (b) suggesting the appropriateness of including retrieval effectiveness in the model. Figure 2 shows Wilson's model adapted to show this instantiation and to include retrieval effectiveness.

The boxes relating to activating mechanisms and intervening variables have been amended in Figure 2 to include those values (underlined) found to affect retrieval effectiveness. A new box for retrieval effectiveness has been added, which includes the *high relevance* value that links to the other values to form the instantiation of those parts of the model to which the study related.

Limitations

The study reported here was limited in a number of ways. The measure of relevance was crude in that a simple dichotomous classification was used. Relevance judgements were made based on a rerun of the original experimental searches. Although in each case this was conducted shortly after the person's search, the potential inaccuracy of doing so in an environment where "the collection" of documents is subject to rapid and constant change is acknowledged. Retrieved documents were not opened and examined in detail for relevance by the researchers, thus resulting in the possibility that relevance may have been under- or overestimated. Nor were relevance judgements rated by independent judges. The fact that more than 4,500 items had to be judged for relevance meant that, within the limits of available resources, it was not possible to employ independent judges.

In relation to the results of the study, the factor analyses accounted for a relatively small percentage of the variance in the variables used (45.3% for study approaches, 38.4% for Internet perceptions, and 48.6% for cognitive styles, age, and gender). Although the regression model predicted relevance at a statistically very significant level ($p = .010$), total variance in the dependent variable accounted for by the model was only 20% at maximum, suggesting the need also to study other possible influencing factors. Such factors—for example, search strategies—did not form a part of the analyses reported here.

Searching was also conducted in constrained experimental conditions. The experiment was restricted to searching on one prescribed topic. The study was also limited in that participants were searching to satisfy a vicarious information need, and the experiment entailed only one search topic, with its own particular characteristics. As noted in the Method section, the topic was designed to induce the generation of search terms which were more general than terms given in the task instructions. Other searches designed to elicit the generation of complementary types of search formulation (e.g., the generation of terms narrower than those given in the task instructions) were not included. Any generalization from this experiment should thus be drawn only with some caution.

Conclusions

It is interesting that relevance emerged relatively strongly in the factor analyses as a defining variable differentiating the different clusters of variables representing

study approaches, Internet perceptions, cognitive styles, age, and gender. It is also interesting that a pattern of findings emerged from different types of analysis that maps well onto the results of previous research into Internet perceptions among a broadly similar group of academically experienced and successful university students, as well as onto the results of a number of previous studies relating to gender differences and the effects of self-efficacy.

However, the research also raises many questions, failing to confirm a number of previous findings in relation to the role of experience and wholist/analytic cognitive styles in searching, and saying nothing about the psychological mechanisms behind the differences that were observed. Nor do we know the extent to which the differences found here may apply across different types of search task, less constrained search conditions, and different populations of Internet users.

Saracevic (1991, p. 85), notes that human individual differences have a major impact on the performance of IR systems. However, he goes on to remark that:

> But as far as the present designs and operations of IR systems are concerned, all this does not matter. The present design of IR systems by and large does not accommodate human variability in IR tasks that culminate in searching and retrieval . . . It is not only that the technological end of IR systems should increase their understanding of people, but the people end of such systems, the information professionals, should also increase their understanding of people and their variability.

Whether we are aiming to enhance machine or human components of IR systems—or interactions between both—we arguably need more knowledge of the ways in which the needs of information seekers differ. It is possible that the interaction between self-efficacy, gender, and cognitive styles may be an important factor in models of human–computer interaction capable of driving the development of enhanced IR systems.

Gender and cognitive style are relatively fixed and not malleable. They thus arguably require adaptability on the part of systems if differences in retrieval effectiveness attributable to them are to be accommodated. Self-efficacy may be much more malleable, and may therefore be a reasonable focus for user training and development. However, we are far from possessing any robust empirically validated model of human–computer interaction capable of helping us design improved IR systems. At a theoretical level, a number of human individual difference factors map well onto aspects of system design (e.g., Ford, 2000). However, clearly much more research is needed—in particular:

(1) in more naturalistic, less constrained conditions;
(2) using more complex and meaningful measures of relevance;
(3) across a range of different types of search task;
(4) in relation to a range of different populations of Internet users;
(5) taking into account information seeking strategies as well as results;
(6) making use of a range of different search engines.

Arguably, further investigation could usefully employ qualitative and quantitative approaches in triangulation to illuminate the type of relationships found here. Although such triangulation is by no means appropriate in all contexts, it is highly appropriate to the focus of the present study in that many of the questions raised by the statistical analysis arguably require for their understanding qualitative data relating to the complex and subjective nature of the relationships between search behavior and the personal meaningfulness to each searcher of the activity in which he or she is engaged (in this case, an artificial, constrained and for some, an anxiety-provoking, experiment). It would be useful for such research to take into account aspects of searching including individuals' expectations, intentions, attitudes, reasoning and emotions. It is possible that models of retrieval processes and effectiveness—particularly models capable of identifying manipulable factors, in users as well as systems, that can help system designers produce better systems and searchers improve the effectiveness with which they search—may require a subtle blend of the objective and generalizable with the subjective and context-bound (Ford, 1999b).

Acknowledgements

Grateful acknowledgement is made to the UK Arts and Humanities Research Board for funding the project of which the present study formed a part, and to the students who gave generously of their time to take part in this experiment.

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APPENDIX
ITEMS FROM THE "INDIVIDUAL DIFFERENCES" QUESTIONNAIRE

Except where otherwise stated, responses were made using the following scale:

Strongly agree		Not sure		Strongly disagree
○	○	○	○	○

Internet perceptions

I usually only look at things on the Internet that have been suggested to me.

Despite its complexity, I generally manage to find my way around the Internet fairly effectively.

I rarely find anything useful on the Internet.

I usually manage to keep "on target" and avoid too much irrelevant material when using the Internet.

I'm prepared to plough through quite a lot of irrelevant information in case there's something useful I might otherwise miss on the Internet.

If I had to choose only one, I'd prefer keyword searching to browsing (hypertext) on the Internet.
The Internet is too unstructured for my liking.

I personally think that the graphical elements of the World Wide Web (i.e., pictures, icons, graphics, etc., as opposed to just text) make me much more likely to use the Internet than if it were just text based.

When I use the Internet, I feel as though I'm not as "in control" as I would like.

My advice to someone like myself would be: the best way to learn to use the Internet is to explore everything broadly to get a comparative "feel" of the various aspects/tools before getting down to mastering any one in depth.

I tend to get lost when using the Internet.

It's best to use the Internet only when you have a well defined plan (rather than just browsing around).

Cognitive complexity

I am uncomfortable with problems where no one solution is obviously the best.

I am the sort of person who almost always sees both sides to a question.

When faced with a problem, I am more likely than most people to look at it from a number of angles.

I have found it best to think in terms of "black and white," rather than of "varying shades of gray."

Study approaches (illustrative items for each subscale)

Deep approach

Intention to understand

I usually set out to understand for myself the meaning of what we have to learn.

Active interest

Often I follow up interesting ideas mentioned in class.

Relating ideas

I try to relate ideas I come across to those in other areas or other courses whenever possible.

Use of evidence

I look at the evidence carefully and then try to reach my own conclusion about things I'm studying.

Surface approach

Intention to reproduce

I try to find books which give me just what I need, so I don't have to work things out for myself.

Passive learning

There's not much point in me trying to think through the implications of what I've read.

Unrelated memorising

Although I can remember facts and details, I often can't see any overall picture.

Fear of failure

Sometimes I worry about whether I'll ever be able to cope with the work properly.

Strategic approach

Intention to excel

It's important for me to feel that I'm doing as well as I really can on the courses here.

Effective time management

I generally make good use of my time during the day.

Experience

Responses were made using the following scale:

No previous experience Extensive experience

○ ○ ○ ○ ○

Level of experience of searching the World Wide Web for information using a keyword search engine.

Level of experience of using the Alta-Vista search engine.

Level of experience of boolean searching.