

A Cognitive Model of Document Use during a Research Project. Study I. Document Selection

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This article proposes a model of document selection by real users of a bibliographic retrieval system. It reports on Part 1 of a longitudinal study of decision making on document use by academics during an actual research project. (Part 2 followed up the same users on how the selected documents were actually used in subsequent stages.) The participants are 25 self-selected faculty and graduate students in Agricultural Economics. After a reference interview, the researcher conducted a search of DIALOG databases and prepared a printout. The users selected documents from this printout; they were asked to read and think aloud while selecting documents. Their verbal reports were recorded and analyzed from a utility-theoretic perspective. The following model of the decision-making in the selection process emerged: document information elements (DIEs) in document records provide the information for judging documents on 11 criteria (including topicality, orientation, quality, novelty, and authority); the criteria judgments are combined in an assessment of document value along five dimensions (epistemic, functional, conditional, social, and emotional values), leading to the use decision. This model accounts for the use of personal knowledge and decision strategies applied in the selection process. The model has implications for the design of an intelligent document selection assistant.

Introduction

The purpose of this longitudinal study is to explore two issues: (1) how real users select documents for their projects; (2) how the selected documents are actually used in subsequent stages. The ultimate goal is to improve

IR system by incorporating users' document selection and use behavior.

Document selection is the endpoint of a bibliographic search. From there, the selected document may proceed to the next stage: document use (reading and citing). Figure 1 depicts three major decision points of document use along the stages of document seeking and use during a research project. The solid box indicates the process in which the decision about a retrieved document is made. The dotted box depicts the decisions about reading and citing the retrieved document in later stages; reading and citing interweave. This research aims at the decision making processes *across* these different stages in a real life situation.

Previous studies that have examined real users on either document selection or citation motivations are, among others, Barry (1993), Bonzi and Snyder (1991), Brooks (1986), Liu (1993), and Park (1992). In this study, data from real users in real situations were collected at both the outset of their projects and the conclusion of the same projects. The resulting longitudinal data reflect users' information needs (presearch interviews), document selection process (concurrent verbal reports while making decisions), and document use (postproject interviews).

This article reports on Part 1 of the study—the document selection behavior drawn on the concurrent verbal reports. Document selection is a decision process in which the user evaluates a retrieved document based on its surrogate obtained from a bibliographic IR system to decide whether or not to further pursue the document: to browse the actual document, to obtain a copy of the document, to read the document, or to make a reference to the document. Document selection is not just about what kind of final decision a user makes about a retrieved document; the more important question is “what are the processes

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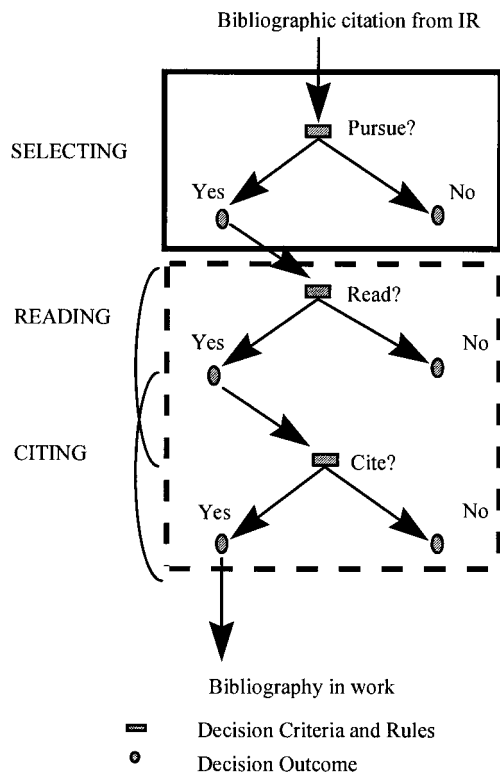


FIG. 1. Document use at different stages.

and factors involved in arriving at a decision?" The focus should be on the process and structure of document selection in real-life situations, not merely the decision outcomes or relevance counts. This study examines what components are relevant to the users' decisions and what cognitive process may have occurred during the selection.

The conceptual framework of the study is based on an examination of literature on relevance and of decision making, both from a cognitive point of view.

Cognitive Approach to Relevance

Relevance is a central concept in information science. Over the last 3 decades, it has received much thought and debate. From this discourse emerged a variety of terms, each emphasizing a different aspect of the concept relevance broadly construed, among them Logical Relevance (Cooper, 1971; Wilson, 1973), Situational Relevance (Wilson, 1973), Pertinence (Foskett, 1972; Kemp, 1974), Utility (Cooper, 1971, 1973), Objective Relevance and Subjective Relevance (Swanson, 1986), and Psychological Relevance (Harter, 1992). The realization that relevance is a central and fundamental notion in IR is nothing new when seen from a system's perspective. The performance of an IR system is measured frequently by its capability for retrieving relevant information. However, relevance in IR as a concept understood intuitively has not been defined precisely. In its simplest format,

relevance is a relationship between a *need* and a *document* judged by a *person* (Saracevic, 1975). After a close look at each of these concepts, the complexity of relevance in IR becomes clear. The *need*, as Belkin et al. (1982) argues, is difficult to articulate, given the fact that the user is in an "anomalous state of knowledge" (ASK). An expressed need (request) must be translated into a compromised need (query) for IR interaction (Taylor, 1968). The *document* representation in current IR is created most often by an entity-oriented approach rather than a request-oriented approach (Soergel, 1985). The *person* as a judge of relevance brings into the task his/her perspective, background, knowledge, and situation (Schamber, Eisenberg, & Nilan, 1990). Two frames of reference for relevance judgment were proposed by Swanson (1977): (1) relevance means that the document meets the information need seen by the requester; (2) relevance means that the document and the request are on the same topic.

Two major empirical studies on relevance judgment, funded by the National Science Foundation, were conducted by the Case Reserve University (Rees & Schultz, 1967) and the System Development Corporation (Cuadra & Katter, 1967). These studies suggested more than 40 variables that might affect relevance judgment; not all of them were examined. Relevance in both projects was judged by solicited judges in experimental settings rather than by real users in real-life situations.

The shift of empirical studies of relevance from a system-oriented approach to a user-centered approach or both approaches seems inevitable as a result of the thrust of the cognitive viewpoint in information science in the late 1970s (Ingwersen, 1987, 1992). Human psychological factors, such as cognitive states and affective feelings, are responsible for users' certain IR behavior (Kuhlthau, 1993; Nahl and Tenopir, 1996). More and more researchers believe that relevance studies should observe real users in natural settings holistically rather than study recruited judges under experimental conditions. In Schamber's comprehensive review (1994), she advocates that relevance studies focus on real-life situations from the human information perspective. Several studies of relevance criteria in the last decade observed various real users in real-world situations in which the users needed information useful for their tasks at hand (Barry, 1993; Cool, Belkin, Kantor, & Frieder, 1993; Park, 1992; Schamber, 1991; Wang, 1994). In these user-centered studies, qualitative methodology was applied to collect data and users were not given a predefined set of criteria to perform relevance judgment or document selection; user criteria were derived directly from content analysis of verbal or written reports. In general, these studies suggest that topicality alone is not enough to make decisions and other factors also underlie users' relevance judgment. These factors will be detailed and compared in the discussion section. After an in-depth analysis of the concept topicality, Green (1995) points out topicality is only part

of the subject content of a document. In document relevance studies, most decisions were based on information elements in a document surrogate, such as title, author, journal, descriptor, etc. The studies by Janes (1991) and Bruce (1994) investigated how some of these elements contributed to relevance estimation. Froehlich (1994) proposes that the study of users' relevance judgments as a process of hermeneutics can evolve a better conceptual framework for designing and developing IR systems. In 1994, the *Journal of the American Society for Information Science* introduced a new series of special topic issues with the first issue devoted to relevance research.

Human Decision Making

The studies of decision making from a cognitive perspective can bring a new dimension into the discussion of relevance and suggest a framework and methodology for studying relevance judgments beyond judgment itself. Payne (1982) pointed out that a decision task is different from a judgment task in that it focuses on dissimilarity among alternatives, includes a justification process, and involves more dimensional information processing. This view is important to our study, because we assume that judging relevance is not the same as deciding on the use of a document. For real users, the meaningful task is to make a decision, not merely a relevance judgment.

Decision making is a problem-solving process that involves information acquisition and processing. The purpose of processing information in decision making is to apply decision criteria that are used to evaluate alternatives. The lens model, also called cue theory, developed by Brunswik (1952) depicts the process of a judgment J about some distal object D by integrating information from a set of cues (X_1, X_2, \dots, X_n) about the object. For example, disease can be judged by evaluating a series of symptoms.

Decision makers do not simply rely on external information available to them, but also introduce new information from memory when constructing a cognitive representation of a decision task (Huber, 1983). They often acquire a limited amount of information and "satisfice" rather than "optimize" their decisions (Simon, 1956). That is, human rationality in decision making is bounded by the situation and by human mental computational powers. Decision makers are unlikely to work out the detailed scenarios. They are more likely to focus on some aspects and on some values while neglecting others. Other factors affecting decision behavior are decision context (e.g., buying a car, selecting a university, and voting) and choice situation (what are the alternatives, risks, etc.).

It is believed that in complex problems the decision process is guided by decision rules (Montgomery, 1983; Svenson, 1979). One example is the dominance rule: choose A over B if A is better than B on at least one attribute and not worse on any other attributes.

There is a clear analogy between purchasing goods and reading documents: Both are need-driven; both involve decision making based on value judgments; and both consider the cost (money or time) of acquisition. The study of consumers' choice behavior explains why consumers make the choices they do. Sheth et al. (1991) propose that consumers' decisions are influenced by five consumption values:

Functional value—the perceived utility acquired from an alternative's capacity for functional, utilitarian, or physical performance;

Social value—the perceived utility acquired from an alternative's association with one or more specific social groups;

Emotional value—the perceived utility acquired from an alternative's capacity to arouse feelings or affective states;

Epistemic value—the perceived utility acquired from an alternative's capacity to arouse curiosity, provide novelty, and/or satisfy a desire for knowledge;

Conditional value—the perceived utility acquired by an alternative as the result of the specific situation or set of circumstances facing the choice maker.

For example, buying a Japanese car for fuel economy reasons is a consideration of the vehicle's functional value, while choosing a Mercedes Benz may be based on that car's social value. Christmas cards and wedding gowns have conditional value. The combined value of the goods underlies the choice.

Conceptual Framework and Research Questions

Expanding on the lens model and adopting the consumption value framework, we arrive at our proposed document selection model as depicted in Figure 2. The decision process consists of several components in an influence chain.

In this model, a document (distal object) is represented by a set of document information elements (*DIEs*) as clues (cues); *DIEs* are processed to judge a document on several *criteria*; the *criteria* are, in turn, applied to judge document *values*; finally, the document values form the basis for the document selection decision. Considering this process from its end result, our document selection model assumes that a user wants to pursue a document only if he/she perceives some *value/worth* of the document. The assessment of document value is based on user *criteria*, but the two are not equal. *DIEs* in document records provide clues to *criteria*. In the process of analyzing a document record, users bring *personal knowledge* to bear on interpreting *DIEs* and on drawing conclusions about document *criteria*. The whole decision process is governed by *decision rules* that determine how much information is processed before a decision is reached. Based on this model, the following questions are raised:

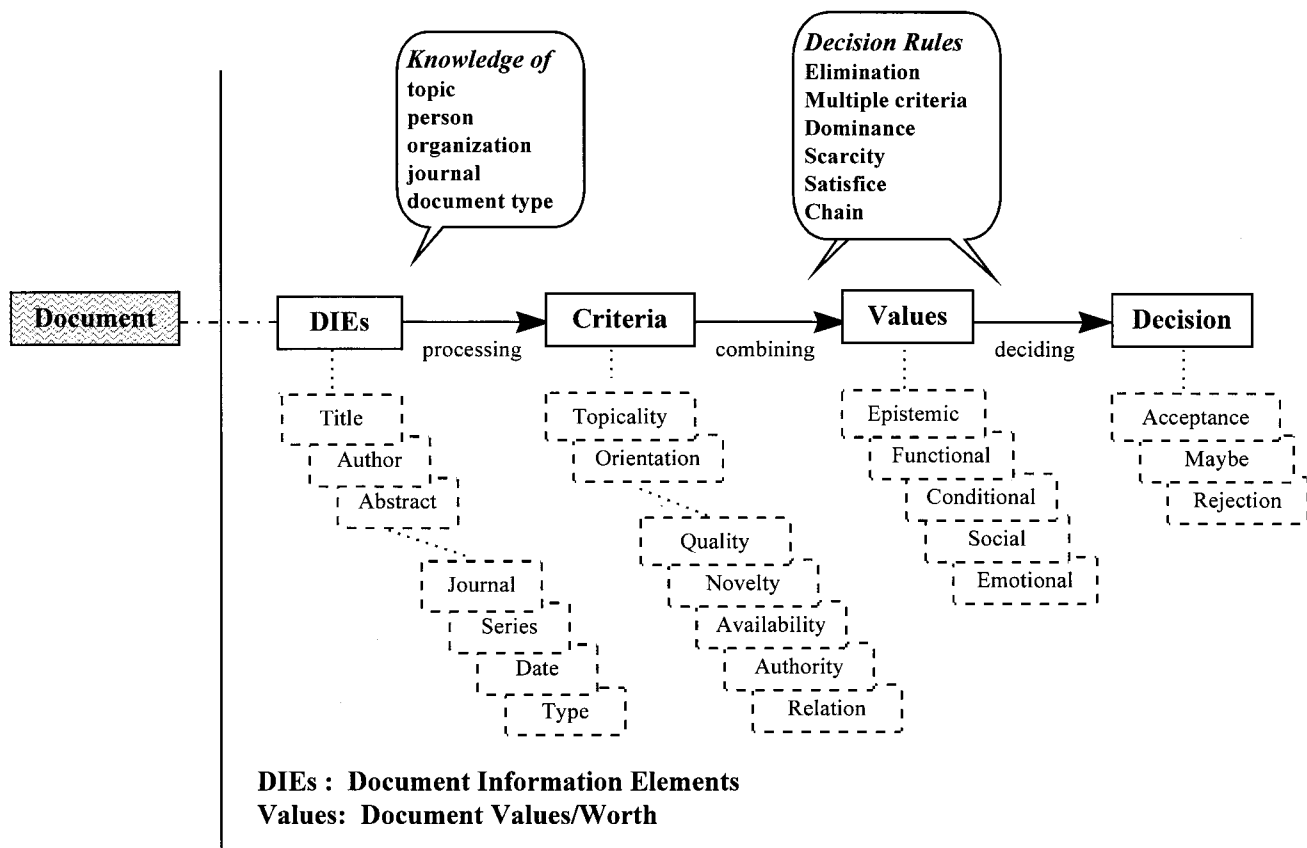


FIG. 2. Document selection model.

- (1) What are the decision outcomes?
- (2) What are the *document values* and their relative importance?
- (3) What are the *user criteria*, how are they derived from DIES and how are they applied in assessing document values?
- (4) What *DIES* are used and how are they applied in judging document criteria?
- (5) What *personal knowledge* do users bring to bear on interpreting DIES?
- (6) What are the *decision rules* used in document selection?

Document values are drawn from consumer theory, and the five consumption values (functional value, social value, emotional value, epistemic value, and conditional value) were redefined to fit the context of IR; their definitions are given in the results section. *Criteria* are derived directly from content analysis of pilot verbal data based on previous user relevance studies. Specifically, topicality can be the most frequently used criterion; the others include document orientation and level, subject area or discipline, novelty, quality, recency, availability, and the situational criteria relation and authority. *DIES* are the smallest meaningful components of a bibliographic record, the basic units for document information; except for a few DIES derived from users' verbalization of wishes, such

as table of contents or citation status; most DIES are from retrieved records, in which one field in a record may contain several DIES. Examples are title, collective title, series, author, journal, document type, abstract, year of publication, etc.; a complete list with definitions will be presented in the results section. For each pair of components in Figure 2, there might be some kind of relationship between them. For example, certain DIES might be good indicators for certain criteria; certain document values may result in certain decisions. Decision rules govern the overall process. Knowledge plays an important role in processing information and applying criteria.

Methodology

Document selection is a cognitive process subject to the control of the user. The most appropriate approach for investigating such a process is qualitative inquiry. The best available method, used by many researchers to study the cognitive processes of human decision making, is to trace the thinking process by *think aloud* or concurrent verbalization. The underlying assumption is that "the information that is heeded during performance of a task, is the information that is reportable; and the information that is reported is information that is heeded" (Ericsson &

Simon, 1993, p. 167). Reliable verbal data can be obtained if (a) the information process occurs under cognitive control not automatically; (b) the information is in focal attention; and (c) the user is not under high cognitive load or distraction. Level 2 verbalization, intended to solicit a user's natural thoughts, requires the user to re-code nonorally encoded thoughts, but does not change the structure or the process for performing the main task (Ericsson & Simon, 1993). Strong empirical evidence supports this claim (Biehal & Chakravarti, 1989; Biggs & Rosman, 1993; Fidler, 1983; Payne, Braunstein, & Carroll, 1978; Schweiger, 1983). The design of this study conforms to the conditions for obtaining level 2 verbal data. Content analysis of the recorded verbal protocols can reveal the decision elements, structures and processes; how information is processed and how the rules are applied by individuals.

Participants

This research was carried out in the Department of Agricultural and Resources Economics at the University of Maryland College Park in the summer of 1992, where the first author worked as librarian. There were 25 participants (11 professors and 14 graduate students) who had information needs for their research projects and were willing to participate. Their research projects were journal papers, grant proposals, dissertations, Masters theses, dissertation proposals, etc.

Data Collection

As an information need arose, the researcher interviewed the participant and immediately conducted an on-line search through DIALOG databases. Two identical copies of the printout of the retrieved citations in full record format were prepared for the following selection sessions. A document selection session was scheduled at the earliest convenience of the participant, usually within 2 days. The participant received the printout at the start of the selection session, and the researcher had the other copy. The participants were asked to *read aloud* while attending to the information in the printout and to *think aloud* while evaluating the information and making decisions. Immediately after the participant made decisions on all the documents, he/she was given a second chance to go through all the selected documents to reject any selected documents; this is called the *anchored judgment*. In making the anchored judgments, the user was also asked to either sort or rank the set of selected documents in his/her preferred way; he/she was reminded that his/her previous decisions could be changed. Both sessions were audio-recorded, and the concurrent verbal report was transcribed into text for analysis.

Neither the model or the list of relevance criteria were presented to the users before or during data collection. The participants were asked to perform their selection

process as usual. The citations and the available DIEs in a citation served as stimuli for their information processing and decision making.

The verbal reports that occurred during the process represent the typical decision behavior because the task was performed across a substantial number of document records. Overall, the users were able to verbalize, to some extent, the information processing and thinking processes underlying their document selection. However, because the verbal reports were only a subset of all thoughts that occurred while performing a decision task and also because there were differences across users in articulation, the results can only be viewed as indicative rather than conclusive. For instance, when no case was found about a criterion from a participant, it might be attributable to a failure of verbalization, and one could not conclude simply that the user never considered the criterion. Not all the components of the model are equally observable by the design of this study. The sparse data obtained about document values suggest that level 2 verbalization offered a limited view favoring epistemic and functional values; level 3 verbalization might be needed for more complete reports on document values, especially the emotional value. In most cases, the users seemed to report decisions right after mentioning criteria without indicating specifically what value category was applied to the document; in other cases, the document values were mentioned, but not the applied criteria. These are clearly the limit of the level 2 verbalization method used to collect data.

Coding and Data Analysis

The emphasis of this study is on content analysis of verbalized thoughts. A coding scheme based on the conceptual framework (Fig. 2) was developed prior to the data analysis, which was not presented to the participants. The scheme was constantly modified throughout the data analysis. Figure 3 is the scheme in two levels (the detailed coding scheme is given in Wang, 1994). All the transcripts were coded and double checked by the first author. Cases with inconsistent codings were resolved by either revising the coding scheme or reevaluating both codes to resolve the difference. The data collection method and the coding scheme were pretested in a pilot study involving two people; these pilot data were not included in the study.

Coding reliability was carefully considered. Many of the categories (such as Search context, DIEs, and Decisions) are straightforward and coding reliability is not an issue. Coding reliability for the abstract and complex categories (category 5 Personal Knowledge, 6 Criteria, and 10 Document Value) was checked by two recruited coders; both were students in an MLS program with cataloging experience. The two students were given a randomly selected identical set of 25 documents and written coding instructions with examples. The coders were not

(2) Participant		(6 7)	Orientation/Level
(2 1)	Status	(6 8)	[not used]
(2 2)	Experience	(6 9)	Availability
(3) Search context		(6 10)	Reading time
(3 1)	Method	(6 11)	Special requisite
(3 2)	Project	(6 12)	Authority
(3 3)	Stage	(6 13)	Relation/origin
(3 4)	Knowledge of topic	(7) Decision rules	
(3 5)	Intended use of literature	(7 1)	Elimination
(3 6)	Literature (exists?)	(7 2)	Multiple-criteria
(3 7)	Amount needed	(7 3)	Dominance
(3 8)	Amount to judge	(7 4)	Scarcity
(4) DIEs mentioned		(7 5)	Satisfice
(4 x)	DIE's notations	(7 6)	Chain
	[This category reflects the sequence of DIEs mentioned. It is not hierarchically structured, e.g. (4 1 8 5) indicates the user examined title first, then author, and abstract.]	(8) Decisions	
(5) Knowledge of			[This is not a hierarchical category only used to record decision outcomes]
(5 1)	person	(9) Anchored decision	
(5 2)	organization	(9 1)	rejection
(5 3)	journal	(9 2)	ranking
(5 4)	topic	(9 3)	grouping
(6) Criteria		(10) Values	
(6 1)	Topicality	(10 1)	Epistemic
(6 2)	Novelty	(10 2)	Functional
(6 3)	Discipline	(10 3)	Conditional
(6 4)	[not used]	(10 4)	Social
(6 5)	Expected quality	(10 5)	Emotional
(6 6)	Recency		

Note:

The third level is for actual values of the variables, e.g. (6 1 1) not clear, (6 6 3) too old, (7 6 1) comments-criticisms, etc. (a complete scheme is in Wang, 1994)

FIG. 3. Coding scheme.

told about the purpose of the study, the model, or the research questions. The overlap between the researcher and the invited coders was 78% and 77%, respectively, well within the acceptable level (0.67–0.8) recommended by Krippendorff for drawing tentative and cautious conclusions in exploratory qualitative studies (1980, p. 147).

A computer program for qualitative data analysis, called NUD*IST (Non-Numerical Unstructured Data Indexing, Searching and Theorizing), was used to analyze the coded protocols. The unit of the analysis is the verbalization of the decision on a single document represented by a bibliographic record in the printout.

Member checking through follow-up conversations with some of the participants was used to validate the model.

Results and Findings

The results are presented in accordance with the model (Fig. 2), going from right to left. (More detailed results are given in Wang, 1994.)

Decisions

The outcome of document selection was not binary, not simply acceptance or rejection. Some documents were accepted strongly, "I want to see it right away"; others less enthusiastically, "I will browse it, but not to spend too much time"; still others were judged "maybe," "It's a question mark." The maybe set was likely to be ignored later; half of the users did not examine it in the anchored session. The rejected documents seemed to be in a spec-

TABLE 1. Summary of values and decisions as mentioned.

Document	Epistemic	Functional	Conditional	Social	Emotional
Accepted	9	30	1	13	2
Maybe	2	3	8		
Rejected	19	18	4		
Column total	30	51	13	13	2

trum as well. For example, “Definitely no,” “Skip this one,” and “Probably not” were representative responses. The results of the 25 users’ decisions are summarized as follows:

Total number of documents retrieved	1288
Range of retrieved documents for one user	21 to 104, average 52
Total number of documents accepted	470
Range of accepted documents for one user	5 to 53, average 19
Ratio of acceptance for one user	11–77%, average 37%

Document Values and Their Relationship with Decisions

Document value is the user’s perception of the desirability or potential utility of a document. Utility is the capacity to satisfy a need. After judging the utility of a document, a user may comment on its value, such as “This book looks really worthwhile” or “It’s not worth the effort.” A total of 109 mentions of document values revealed five types of document values: epistemic, functional, conditional, social and emotional values. The value judgment and related decisions are summarized in Table 1.

1. *Epistemic value*—the perceived utility of a document to satisfy a desire for knowledge or information that is unknown. By this definition, it can be assumed that epistemic value is the prerequisite for all other types of value, and documents without epistemic value will definitely be rejected. When mentioning the other four types of values, a user might or might not explicitly refer to the existence of the epistemic value for a document; therefore, the document was not coded for the epistemic value because it was not explicitly verbalized. For instance, if a user verbalized functional value, he/she might have found it unnecessary to explicitly mention epistemic value as well. In this case, epistemic value was implied when functional value was mentioned. Because the content analysis in this study only coded the data at face value (what was said), the interpretation of the 30 cases about the epistemic value should be put in perspective. That is, this value in nature is the prerequisite for all other types of values in document retrieval and the actual count should be more than 30. At the epistemic level, the user seems to relate the document to his/her information needs or interests in general, not just to his/her task at hand.

“I’d just like to know. I am curious about this document.”

“I need to know, although I don’t know how useful it will be.”

“There is something interesting, but I won’t use it for my research now.”

“This is going to be fairly good . . . it will tell me a lot of details about real world approaches to my problem [which I don’t know]. That will be useful for me.”

There were 30 documents of epistemic value (Table 1). In 24 cases this value was verbalized and positive; the decisions were 8 acceptance, 2 maybe, and 14 rejection. For the remaining six cases, where the epistemic value was uncertain, only one document was accepted, and five were rejected. Although there was no mention of negative epistemic value, some documents might fall into this category. Positive epistemic value alone may not result in acceptance of a document.

2. *Functional value*—the perceived utility of a document to make a contribution to the specific task at hand. At this level, the document is useful for the project. When a user believes that a document can be used as a theoretical basis, empirical support, methodological guide, or simply as a good citation, the document is predictably accepted. A functional document is always topically relevant and task-related.

“I will probably look at this article because there may be some theoretical basis or information that I can draw on to develop the kind of model that I want to use.”

“It is not that I think it’s going to give me ideas so much. It is sort of a good background thing. I need to have it for [a citation].”

“I don’t know how useful it will be.”

“It is not directly related to the topic. . . . I want it for another paper.”

The functional value was the most-mentioned type with 51 documents (Table 1); it was mentioned positive, uncertain, or negative. The following summary indicates that when functional value is positive, the acceptance of a document is likely to happen and vice versa.

	Functional value	Accepted	Maybe	Rejected
positive	20	20	0	0
uncertain	13	8	3	2
negative	18	2	0	16

3. *Conditional value*—the perceived utility of a document is yet to be decided circumstantially. There are some “ifs” to be answered with regard to some aspects of the project before a decision can be made. It is likely that some of the conditional documents can become functional documents if the situation changes.

“This is going to be very useful for something Dr. X and I might move on, though it’s unclear. I don’t know yet. That sounds promising.”

“This could have potential. It depends on whether I want to concentrate on agriculture.”

Thirteen documents were verbalized for having conditional value. Of which, 1 was accepted, four rejected, and eight maybe (Table 1). Users tended to put these conditional documents into the maybe pile.

4. *Social value*—the perceived utility of a document in association with specific social groups or with individuals such as academic advisor, famous figures in the field, etc. When the user is associated with the author in some way, he/she feels it is important to know what the document says and the acceptance of the document is predictable.

“Oh, X, very famous man. . . . I am curious to know what he says.”

“. . . from World Bank. . . . I should be aware of . . . I don’t expect to get much from it [for the project], except to know how to argue with those people.”

“Oh, it’s by X [advisor], I will read it. . . . I better put it high.”

As the first example indicates, some users will read everything published by a particular author. Thirteen documents were mentioned for having social value; all were accepted (Table 1).

5. *Emotional value*—the perceived utility of a document stemming from its capacity to arouse feelings or affective states. Reading a document might cause positive or negative feelings.

“I see that one of these guys [authors] is a jerk.”

“. . . by X [former instructor] whom I just hated most in the University of Y.”

Despite the bad feelings, this user accepted both documents. This value was mentioned only twice negatively by one user; but it was mentioned positively once in the pilot study. Its existence was confirmed by member checking, in which the model was presented to some of the participants after data analysis to verify its validity. It is hard to predict whether or not a user will accept a document by a disliked author.

User Criteria and Their Relationship with Document Values

Criteria are a set of filters that users apply to a document in order to assess its value/worth. In applying crite-

TABLE 2. Criteria as mentioned.

User mentioned criteria	Total documents	Percent %	Total users*
Topicality	871	65.3	25
Orientation/Level	126	9.4	21
Discipline	36	2.7	15
Novelty	71	5.3	17
Quality	126	9.4	21
Recency	38	2.8	15
Reading time	11	0.8	7
Availability	3	0.2	3
Special requisite	14	1.0	7
Authority	15	1.1	11
Relation/Origin	23	1.7	13
Column total	1334	99.7†	—

* Due to rounding.

† Number of users mentioning this criterion at least once.

ria to judge document value, two kinds of criteria occurred: the document content information criteria concerning topic, content, depth, style, etc., and the situational criteria relating a document to the user’s professional and personal situation—the things beyond the document information content. For example, recognition of the author can change the user’s value judgment, especially when there is a special relationship between the user and the author. Table 2 summarizes the use of criteria.

1. *Topicality*—what the document is about as the user sees it with respect to his/her task at hand. It is a users’ perception of whether or not the topic of a document is relevant or related to the topic of his/her project. The answers to this question are differentiated and do not give a simple relevance ranking.

“On the basis of the title, I will look this one up. This is exactly a question I need to be concerned with . . .”

“Well, the methodology is very relevant and the topic is different.”

“He applies it [topic] to a completely different field . . . I like to read it because it has a summary of everything that has been done.”

“I think part of this is relevant, like consumption function.”

All users mentioned this criterion. The following values for topicality emerged:

- nonmatch
- unclear
- facet nonmatch
- related
- facet match
- match (on topic)
- too specific/narrow
- too general/broader
- match other task
- providing context
- bibliographic source.

TABLE 3. Co-occurrence of value and criteria.

Criteria	Co-occurred with value type*				
	E	F	C	S	Em
Topicality	15	13	12		
Orientation		6	2		
Discipline	4	2			
Novelty	2				
Quality		7			
Recency		3			
Reading time			2		
Availability			1		
Special requisite		1			
Authority				6	
Relation/origin				7	2
Column total	21	32	17	13	2

* E: Epistemic, F: Functional, C: Conditional, S: Social, and Em: Emotional.

Notes:

1. Given the nature of level 2 verbalization, the cases in which both the values and the criteria were mentioned indicate the possible relationship between a criterion and a value type.
2. The column total does not match the column total in Table 1 because in some cases, values and criteria did not co-occur, and in other cases, several criteria co-occurred with a value.

This is the most-used criterion; it contributed to 65% of the comments about user criteria; topicality indicates epistemic value, functional value, and conditional value (Tables 2 and 3).

2. *Orientation/Level*—at which intellectual level the document is written and for which audience it is intended. Is it an academic or scholarly paper? Is it a theoretical or an empirical study? Is it a methodology paper or a review of the topic? Is it for academia or for practitioners?

“It seems that this would be a theoretical paper that relates the concept of downside risks to behavior of competitive firms.”

“I don’t need evidence [title word], because it would be an empirical study. That won’t be important [to this project].”

“I know the author. It should be more academic and have more substance.”

Of the 25 users, 21 mentioned this criterion. When the topic did not match, the orientation was usually not evaluated. This is the second most-mentioned criterion, and it contributes to functional value and conditional value (Tables 2 and 3).

3. *Discipline* (called “subject area” in Wang, 1994; Wang & Seorgel, 1993; Wang & White, 1995)—the broader subject area or branch of knowledge to which the document belongs. Economics is an interdisciplinary field; many of its topics are also studied by other disciplines, such as political science, engineering, environment

management, finance, etc. A user may want to include or exclude documents from different disciplines.

“X [author] is working in this area . . . I mean I didn’t know he wrote on this topic.”

“I can’t tell. I don’t know. Are they [the authors] economists or biologists or what?”

This criterion was moderately mentioned by 15 users (Table 2); it might not be a concern when the topics were not interdisciplinary. The following verbal comment indicates its importance in decision making. “If it is too Engineering, I might not be able to understand.” This criterion affects both epistemic and functional values (Table 3).

4. *Novelty*—whether or not the user has seen the document before or whether its content is new to the user regardless of when it was published.

“I found it by myself. I would want to look at it if I haven’t.”

“No. I have read something like that before, similar.”

Seventeen users mentioned this criterion. It ranked number four in frequency (Table 2). Obviously, novelty affects epistemic value. Normally, a user would reject a document without novelty, but there were cases when the user was glad to see the known items, which served as an indicator of the success of the search or would otherwise have been missed.

“I have expected to see this one.”

“This is a good one to have. Another ironic thing, this is a publication which I believe I have.”

5. *Expected quality*—the estimation of the goodness of a document. Expected quality may really mean a positive or negative attitude the user has toward a document before consulting the full document.

“He [author] is good. He knows the subject well. I’ll be interested in this.”

“By X [author], a very good economist. You see the factor I take into account. Who is the one who wrote it.”

“It’s put out by the National Academy of Sciences. This is good.”

“It’s not a high quality journal.”

Quality, ranked number 2 (ties orientation), was mentioned by 21 users. Similar to orientation, if the topic did not match, quality was not judged. Four students did not use this criterion. Quality affects functional value (Tables 2 and 3).

6. *Recency*—the comparative newness of a document with regard to the user’s topic. For some users and topics, a document published 8 years ago may be current, while for others 2 years may be too old. This criterion depends

on the topic and can be overridden by other factors. For example, the first paper on a topic can be timeless.

“’84 is pretty current.” [Search was conducted in the summer of 1992.]

“It’s ’91. What’s going on today [about this topic] you don’t know. . . . I am not interested in two years ago.”

Similar to discipline in rank, 15 users mentioned this criterion; it contributes to functional value (Tables 2 and 3).

7. *Reading time*—user’s sense of whether or not he/she can afford the time to read a document. It is an individual’s judgment based on his/her situation as he/she perceives.

“[I] care about time, I will get rid of this one. It’s not a good journal and . . .”

“It has 266 pages. So, it’s a book. . . . It would be useful to read it if I had unlimited time.”

“But, it is only 14 pages. It might worthwhile glancing through it.”

Seven users mentioned this criterion and it affects conditional value (Tables 2 and 3).

8. *Availability*—the easiness of obtaining a document and the means by which a document can be accessed. The document is accessible if it is in a personal collection, a department library nearby, or on campus, etc. It has to do with the user’s willingness to overcome difficulties in getting a document. To some users, the interlibrary loan service is considered a less acceptable means.

“I don’t have very much expectation on getting much out of this. Journal of [. . .], which you [the department library] have. I will take a look at this one.”

“Actually, there are two reasons [to reject this one]. One reason is that it is difficult to get dissertation . . . It will be too much trouble to go through interlibrary loan. . . .”

“I would like to read it again. . . . I have the journal.”

Table 2 indicates that most users did not seem to consider this criterion at the time of document selection. It can be predicted that some of the documents will not be used in subsequent stages simply because they are “hard to get.” Availability might affect conditional value (Table 3).

9. *Special requisite*—a skill or an equipment that might be required to use a document. If the user does not read the language or a special tool is needed for using the document, it is likely the document will not be used.

“It’s good. Oh, no, it’s in German. The title is extremely interesting.”

Most searches in this study were done on a database without a searchable field for language. This criterion was not often mentioned, because only a few non-English documents were retrieved. Some microformat documents

were accepted because the users were not aware that the back issue newspapers were in microfilm. Like the availability, it was not a major criterion; only seven participants mentioned it 14 times (Table 2). However, in the electronic document space, this criterion may take on added significance. A good example is that a special plug-in is often needed to view, print, listen to or get a digital object on the Internet. This criterion affects functional value (Table 3).

10. *Authority*—the document originates from a person or an agency recognized as an authority figure in the field. This recognition raises the users’ expectation of the utility of the document in general. This criterion is also related to quality.

“I will look at this one. . . . partly because X [author] is a very well-known agriculture economist.”

“Oh, yes, definitely. Because the author is X, one of the big names for the thing.”

Eleven users identified 15 documents written by authority; authority contributes to social value (Tables 2 and 3).

11. *Relation/Origin*—the document originates from a person or an agency that has a special impact on the user regarding his/her situation because of a preexisting relationship, such as advisor, course professor, colleague, affiliated organization, etc.

“Oh, it’s by Dr. X [advisor]. I will read it.”

“She [author] is my classmate in Cornell. I want to see this article.”

“That I probably want simply because I worked with X.”

Over half of the users mentioned this criterion and it contributes to both social value and emotional value (Tables 2 and 3).

DIEs and Their Relationship with User Criteria

The concept of DIE (Document Information Element) was coined for this study to cope with the diversity and inconsistency in record formats across different databases in DIALOG. It is needed for this study because DIEs are seen as the basic units that collectively represent a document to provide clues to the users’ criteria; one field in a bibliographic record from a computer output may contain several DIEs; certain DIEs in users’ wish lists are not yet available in document retrieval systems. Eighteen DIEs were mentioned for being used or needed in applying criteria (Table 4). Across all participants, the four most frequently used DIEs were title, abstract, journal, and author. There were times when the users expressed a “wish” to see the missing DIEs:

“Just not enough to go on to tell me what it is about. No, the abstract and title are so vague.”

TABLE 4. Frequently used DIES.

DIES	Mentions	Percent %	Users*
Title	1282	52.7	25
Abstract	288	11.8	22
Journal	271	11.1	19
Author	232	9.5	24
Geographic location	125	5.1	18
Publication date	62	2.5	18
Document type	59	2.4	17
Author's affiliation	34	1.4	13
Descriptors	29	1.2	11
Language	21	0.9	11
Others†	34	1.4	7
Column total	2437	100	—

* Number of users mentioning this element at least once.

† The eight DIES not listed separately are publisher, document length, volume and issue, subfile, edition, author's expertise, table of contents, and citation status.

"I don't know if they are economists or biologists or what?"

"It might be interesting. . . I'd prefer to have the table of contents."

"If I have seen him cited by others, I will think this one is pretty good."

These cases may seem statistically insignificant in the number of times mentioned, but they should not be ignored because they were needed as clues to criteria at the time of making a decision and were not available in bibliographic records. Table of contents, author's expertise, and citation status (whether or not the document was cited by other researchers) were included in "others" in Table 4. Citation status was not included in Wang's dissertation (1994); further analysis of the data revealed this element. Media (meaning whether the document is in print- or microformat) was not mentioned by any user although it is an indicator for the criterion special requisite.

The participants did not process all the DIES in a bibliographic record. The average number of DIES per user, for a decision, ranged from 1.4 to 3.3. More than half of the retrieved documents were decided by evaluating only one element, while a few documents received attention to as many as six DIES. It is true for all the users in this study that when the evaluation on topicality is positive, such as match, related, facet match, etc., more DIES were further processed.

As the information processing pattern is concerned, it is probably more appropriate to look at each individual's pattern of DIES. The examples of the dominant DIE sequences for individual users include (frequency in parenthesis):

User 1: Title (83); Title → Journal . . . (11); Title → Publication date . . . (6);

User 3: Title (30); Title → Author . . . (11); Title → Abstract . . . (6);

User 8: Title → Author (23); Title (12); Title → Author → Abstract (9);

User 11: Title → Journal (13); Title (10); Title → Journal → Abstract (5);

User 20: Journal → Title (31); Journal → Title → Abstract (14); Document type → Title . . . (11);

User 24: Title (33); Title → Abstract (5). [This user had only two patterns]

Most users started with title. Although title is the first DIE in a record, some users consistently evaluated other DIES before title (e.g., User 20). There were other cases, when the user recognized the familiar authors before he/she attended other information.

"The next one I do want to see. I do know the author. . . I do respect him." [The user confirmed that his decision was based solely on the author and none of the other DIES were checked or needed to be evaluated.]

Table 5 gives the relationship between the DIES and the criteria by cases found in data. The highlights are as follows:

Criterion	DIES as Clues
Topicality	Title, Abstract, Geographic location, Table of contents
Orientation/Level	Title, Abstract, Table of contents, and Journal
Discipline	Journal and Author
Novelty	Title and Author
Quality	Journal, Author, Citation status (whether it is cited by others)
Availability	Journal and Document type
Special requisite	Language was indicated by Title (parallel non-English titles) and Journal (non-English) rather than a searchable field in some databases
Recency	Publication date
Authority	Author (personal or corporate) and Author's affiliation
Relation/Origin	Author

Personal Knowledge

From a cognitive point of view, personal knowledge must be activated to assimilate incoming DIES. The analysis focuses on what types of knowledge were applied and how the knowledge was applied. The first type is *topic*, which is the basis for document value assessment. The knowledge about topic includes WHO was involved (related to knowledge about persons),

"This one I expected. . . We know these guys are very

TABLE 5. Relationship between DIES and criteria.

Criteria	DIEs* as clues to criteria (cases)											Row total
	Ti.	Ab.	Jo.	Au.	GL	PD	DT	AA	De.	La.	Others	
Topicality	631	196	4	5	90	1	1	2	18		3	951
	66%	21%	—	1%	9%	—	—	—	2%		—	99%†
Orientation/level	87	60	32	4	1		2	2	3			191
	46%	31%	17%	2%	1%		1%	1%	2%			101%†
Discipline	2	2	19	8				4			3	38
	5%	5%	50%	21%				11%			8%	100%
Novelty	69		2	21							3	95
	73%		2%	22%							3%	100%
Recency						38						38
						100%						100%
Quality			75	74			4	5			1	159
			47%	47%			3%	3%			—	100%
Reading time							3					3
							100%					100%
Availability			2				1					3
			67%				33%					100%
Spec requisite	12		2							14		28
	43%		7%							50%		100%
Authority				15								15
				100%								100%
Relation/origin				23								23
				100%								100%

* Ti., Title; Ab., Abstract; Jo., Journal; Au., Author; GL, Geographical location; PD, Publication date; DT, Document type; AA, Author's affiliation; De., Descriptor; La., Language; and Others, see Table 4.

† Due to rounding.

involved in the debate on structure change. They wrote the original paper.”

WHAT are the issues,

“That might be useful because food has been left out in the Canadian agreement.”

WHEN it was first discussed,

“[This one is] probably before this tuna-porpoise stuff [was first discussed]”

WHERE the topic is meaningful,

“I see the topic [of the document], I know what it means. . . . Cheap credit could be something in Asia or South America.”
 “Biotechnology is only a promise now. . . . Not for Latin America, my world . . .”

HOW it is related to other topics,

“He applied it to a completely different field, but a lot of corner solutions have been worked out on recreation and demands. I’d like to see it.”
 “Chemical use is related to fertilizer and pesticides. I’d like to know the impact.”
 “. . . ‘Shapley value’ . . . It’s more a kind of game theory.” [Hierarchical relation identified]

The second type is knowledge of *person*, by which the user judges some aspects of the document that were not straightforward in the document record,

“I know X [author]. I think he is good at econometrics.”
 “It [title] sounds incredibly narrow, too applied. But it is by X [author] and it is in JET [Journal of Economic Theory]. So, it can’t be incredibly applied.”
 “Yes. I have read several things from him. [His work is] very good.”

Knowledge about the person(s) who authored the document is often used to judge topical relevance [first example], orientation [second example], and quality. In most quality comments, users indicated their experiences with the authors.

The third type of knowledge is *journal*, by which a document’s quality, orientation, and discipline can be judged,

“It’s in AER [American Economic Review], which is a very good journal.”
 “Federal Register is not theory oriented.”
 “Managerial and Decision Economics. No, it isn’t our journal.”

The fourth type of knowledge is about *agency*: what the organization does and how good its work is,

TABLE 6. Personal knowledge applied.

Knowledge about	Cases	Users*
Topic	60	21
Journal	83	18
Person	105	23
Agency	15	8
Column total	263	—

* Number of users mentioning the type of knowledge at least once.

“She [author] is connected with World Resources Institute, which tends not to be economic approach; it tends to be environmentalist approach, which is not what I want.”

“It’s put up by National Academy of Sciences. This is good.”

“Agency for . . . [organization] usually does not do great work.”

From the 263 cases, the most-commented knowledge category is knowledge of person, the next of journal, followed by topic, and then agency. A comment identified as personal knowledge of the topic is different from a mention of the topicality of a document, in that an elaboration about the topic revealed what the user knew about the topic. Mentions of knowledge about a topic in Table 6 were based on elaboration where, what and how the user’s topical knowledge was used to make decision. The examples given above indicate this point.

Decision Rules

As in any human decision situation, users apply certain rules in their decision making about documents. Rules for document selection are applied either to individual documents or to a set of documents. Table 7 is the summary of the use of these rules.

1. *Elimination rule*—to reject a document, the user looks for an aspect of the document that enables him/her to quickly reject a document. Any one salient criterion suffices for a rejection; usually one DIE is processed to judge one or more criteria and quickly determine one or more document values that are sufficient to reject the document. In a query formulation this corresponds to Boolean AND NOT.

“The next one is Japan. I am not interested in Japan.”

[The title reads “Japan . . .”]

“This is a dissertation. It doesn’t really say very much. I will tend to pass it.”

This rule reflects the least effort principle. If the eyes can browse through the DIEs quickly and identify an obviously unwanted aspect of the document, information processing can be terminated immediately. All users applied this rule during the selection.

2. *Multiple-criteria rule*—as a contrast to elimination rule, the user applies several criteria to accept or reject a document.

“I am not sure. But, it’s worth taking a look at it, because it’s in AJAE [American Journal of Agricultural Economics] and it’s very current.”

“Sounds like more policy-oriented, plus it’s too old.”

This rule seems to reflect the conservative traits of some users. By applying more than one criterion, the user needs to process more DIEs; in doing so, the user confirms that the acceptance is “good” or makes sure that his/her rejection would not “miss anything useful.” All participants applied this rule.

3. *Dominance rule*—of similar documents, the user selects the one document which excels in at least one aspect and is not worse in the other aspects.

“This article is very similar to the previous article. . . . Spring 1980. Probably what I would do is to look at the previous one [1987] . . .”

“Almost the same. But, I don’t like this one, because it has the model. So, I will just take the previous one.”

“This is the 3rd edition and the other is the 4th edition. I will choose the other one.”

This rule was applied by four users in eight cases. It indicates that users do not want to spend time on all of several similar documents, and they prefer to get the one that seemed to be the best for their tasks.

4. *Scarcity rule*—when the user wants more documents, but only a few are retrieved, he/she tends to apply less stringent criteria so that even marginal documents are accepted.

“. . . even though it’s on Canada [facet non-match]. . . . I am going to put this high. It deals with soil erosion [facet desired], which we haven’t seen too many. We have seen a lot of pest management [another facet desired], not much about soil.”

“. . . the theoretical part is not quite useful. If I have a lot of articles, I will probably not go to pull this out.”

Like the dominance rule, this rule occurred in seven cases

TABLE 7. Decision rules applied.

Rules	Cases	Users*
Elimination	382	25
Multiple criteria	323	25
Dominance	8	4
Scarcity	7	4
Satisfice	9	4
Chain	49	12
Column total	778	—

* Number of users mentioning this rule at least once.

by four users, indicating that some users may not have a definite threshold in mind as to what to accept. They adjust criteria according to the search results. It may be true for certain situations in which users feel that having something is better than nothing.

5. *Satisfice rule*—when the user feels that enough documents on a topic or facet have been selected, he/she may stop accepting relevant documents or terminate the selection process on that topic or facet.

“They all look like useful. I am not going to read them all. . . . No, I already picked something on fast track.”

“Grain is good. No, I am getting enough stuff in this area already.”

As opposed to the scarcity rule, this rule is applied when excessive documents were found on the topic or facet. Users have no intention to read all topically relevant documents; users may stop or proceed with the selection process on documents about other topics or facets but ignore this topic completely. This rule was applied by four users in nine occasions.

6. *Chain rule*—when the user identifies documents that are on a special chain, he/she tends to make a collective decision on the set. The relationship that holds the documents on a chain can be the critique article with the original article, papers in a collective volume, a special topic issue by a journal, the paper and its citation by another important paper or author.

“This is a discussion [of another paper]. But, this [topic] is exactly what we want to find out. I will also get the [original] paper.”

“Three articles in a row. I would guess they have a special issue on sustainable agriculture. So, I will probably go get this issue out.”

About half of the users applied this rule in making decisions on 49 interconnected documents. The following case provided evidence that a citation chain could be applied to decide whether or not a document is worth pursuing:

“Probably not, I haven’t seen it cited anywhere.”

Summary of Findings

The twenty-five participants’ verbal protocols about the 1288 retrieved documents provided substantial evidence for the proposed document selection model. Of the five document value categories, epistemic value was the essential one; while it may not result in acceptance by itself, it is the basis for other values. Both the functional value and social value were salient because they often resulted in acceptance. Conditional value put the documents into a pending set until the project was further

defined. Emotional value was observed but not verbalized often; it may or may not affect the selection decision.

Among the user criteria identified in this study (Table 2), topicality was the most frequently mentioned by all participants—not surprising in a task-evoked IR situation. Topicality is essential to epistemic, functional, and conditional values. In many cases, topicality alone sufficed for making a decision; in most other cases, the evaluation proceeded only when topicality was positive. However, this study also found cases in which users skipped topicality judgment and made decision solely based on situational criteria, authority or relation. Both orientation and quality followed topicality as important indicators of functional value. Novelty (ranked 3rd), recency (4th), and discipline (5th) are salient criteria because once they were mentioned they affected the estimation of epistemic or functional value. Either reading time or availability seemed to result in conditional value. Cases for special requisite were attributed only to the small amount of non-English documents that could not be discriminated by the databases used. If the user could not read the language, the document lost its functional value. For the two situational criteria, authority, and relation/origin, their applications are personal, situational, and strategic; both contribute to social and emotional values. Two documents triggered bad feelings due to certain past experiences about the authors that resulted in negative emotional value but accepted.

Not all the DIES available in the document records were used to prompt criteria. Seventeen DIES were used; 10 of them (title, abstract, journal, author, geographic location, publication date, document type, author’s affiliation, descriptor, language) were used by at least 11 participants (Table 4). Title, ranked at the top, provided most of the clues to topicality, orientation, novelty, and other criteria (Table 5). Besides title, abstract was the next most important clue to topicality and orientation. Another important DIE for topicality was geographic location. Both author and journal provided the most clues to expected quality. Publication date mainly cued recency. Author’s affiliation were used to infer discipline. Among the DIES not listed separately in Tables 4 and 5, table of contents, citation status, and author’s expertise, none of which were available to the users, were of significance because they were needed for three important criteria: topicality, quality, and discipline. The frequently used DIE patterns started with title. All the users showed their preferences for DIE patterns. On average, decisions were made after evaluating two DIES; when topicality was positive, more DIES were evaluated.

Personal knowledge applied in the selection process consisted of four types: topic, person, journal, and agency. This knowledge was applied to fill the gaps in document records in order to apply criteria. Six decision rules were identified: elimination, multicriteria, dominance, scarcity, satisfice, and chain rules. These rules focus on either the individual document decision in relation to information

processing or to choices among several documents as alternatives.

Discussion and Conclusions

This model depicts the behavior of this user group and provides a framework for studying different user groups and for studying subsequent document behavior—reading and citing. As inherent in qualitative inquiry, the data collected in this study were rich, detailed, and insightful, but unsystematic and incomplete. The users in this study are experts in research and document use. Therefore, the results should be interpreted with caution. No generalization of the findings will be made, and the model needs to be further tested. Some aspects of the model can be validated by comparing the results in this study with those from similar studies.

Like all decision situations in the real world, document selection from a search result involves uncertainty and cost-benefit tradeoffs. For this user group, most retrieved documents were given a sure decision. The “maybe” decisions were due either to knowledge states (ASK) or insufficient document representation; therefore, some documents were considered to have conditional value. Kuhlthau (1993) discussed the uncertainty in her model of the Information Search Process of library users as a cognitive state.

The notion of document value can be related to notions discussed by other researchers. Specifically, the functional value may well be a synonym for utility or pertinence, which were proposed as an important aspect of or even a substitute for relevance in IR (Cooper, 1973; Foskett, 1972; Kemp, 1974). Social value reflects the social operation of science (Price, 1963). Emotional value is compatible with the studies that included the affective domain in the investigation of information seeking behavior (Barry, 1993; Kuhlthau, 1993; Nahl & Tenopir, 1996). These five values address different dimensions of a document; they underlie decisions. The advantage of grouping them into one class labeled with the document value is having this component link both the criteria and the decision.

Although variables of document attributes and user attributes were listed comprehensively by the two NSF projects in the 1960s, many recent studies advanced relevance research substantially. The studies about real users' relevance criteria identified a set of core criteria across situations and users. Table 8 lists the criteria found in this study that are compatible with those addressed in the other three studies (Barry, 1994; Cool et al., 1993; Schamber, 1991). Because Schamber's dissertation research is not about textual documents as information sources, her results did not include some of the criteria arrived from the document-oriented relevance studies. Park's (1992) work is very relevant to this study because she also observed academic users in real world situations.

Table 8 does not include her factors of user relevance, because they are at a macrolevel.

The comparisons of criteria above suggested that the researchers might have named the user criteria differently, but they identified a core set of criteria beyond topicality across users and tasks. These criteria are based on the user's cognitive states (knowledge and experience), task situation, and personal preference. The studies by Wang and Barry share most of the criteria and DIEs (discussion follows), because their user groups are similar and their methodological designs are similar. Barry focused on the categorization of user-defined relevance criteria beyond topicality, while Wang aimed at building a cognitive model to describe document decision process. Therefore, in Wang's study, the taxonomy of the criteria derived was at a broader level than that in Barry's; and personal knowledge and document value were two separate components and dimensions of the model, not part of the criteria.

Green (1995) suggests that the subject content of a document extends beyond topicality, and topical relevance is not the only primary relationship between a text segment and a user need. Several criteria identified in Wang's model (e.g., orientation/level, discipline, novelty, and quality) pertain to subject contents in addition to topicality. Suffice to conclude that, although topicality is the most important criterion for task-evoked IR, it does not warrant a selection decision.

The studies of real users' relevance also examined the functions of information elements that represent documents. The overlap and unique elements by Barry (1993), Janes (1991), Park (1992), and Wang (1994) are listed in Table 9; differences in naming were considered and resolved.

This study involved more document representation elements; in addition, it found some nonexistent DIEs that were mentioned by the users as needed for making a decision: the table of contents, author's expertise, and citation status (whether or not the retrieved document is cited by others). The number of times these elements were mentioned was small, but their significance cannot be underestimated. They are subject content bearing elements and quality indicators. These missing elements, if they had existed, would have been used by other participants in this study. On the other hand, many existing elements in the records were not needed or used for selection (Table 4). The lack of user relevance related information elements and the inflexible record presentations in current document retrieval (DR) systems reflect the major weakness of document-oriented system design.

It is important to point out that individual users' cognitive structures determine their ability to use the type of information elements necessary for decision making; and they also have a personal preference as to how certain elements should be arranged and sequenced. Therefore, different presentations for retrieved documents should be made available for different users to reduce the cognitive

TABLE 8. Comparison of user relevance criteria from four studies.

Wang (1994)	Barry (1993, 1994)	Cool et al. (1993)	Schamber (1991)
Topicality	Information content	Topic (on topic, part of topic, focus, . . .)	Specificity Geographic proximity
Orientation/level	Depth/Scope	Content/Information	—
Discipline	Information content	—	—
Recency	Recency	Age of document	Currency
Novelty	Content novelty	—	—
	Source novelty		
	Document novelty		
Quality	Accuracy/validity	Goodness, usefulness	Accuracy, consistency
	Source quality	Treatment (depth)	Clarity
	Tangibility	Importance	Dynamism
Reading time	Time constrains	—	—
Availability	Obtainability	—	Accessibility
	Personal availability		
	Availability within environment		
Special requisite	Effectiveness	—	Usability
Authority	Source reputation/visibility	Authority (well-known)	Reliability, expertise
Relation/origin	Relationship with author	Oneself	—
—	Clarity	Presentation	Presentation quality
—	External verification	Format	Verifiability
[Personal knowledge]	Background/experience		
[Emotional Value]	Affectiveness		
[Time as cost]	Cost		Cost
[Epistemic, functional, emotional values]		Values (interest, usefulness, entertainment)	
[Functional value]			Confidence in source
[Emotional value]			Human quality

Note: The shadowed cells compare the criteria across Barry, Cool, and Schamber with related components in Wang's model.

load and improve information processing during the selection process. This need will become even more critical when users make document decisions on a computer screen, where browsability is limited.

Implications for System Design

A major purpose of this study was to acquire knowledge from human "experts" in document selection as a basis for improving DR systems. The model that emerged from the observation of experts can be used to design better DR systems in two ways:

- (1) Build some of the user's decision rules into the selection mechanism of the DR system, thus enhancing DR system functionality by allowing the user to specify a wider range of selection criteria in the query formulation and thus have the system do a better job at document selection. This could be done in the underlying (server-based) DR system or—in a more personalized manner—in a local (client-based) screening program. Allowing the user to better express the actual search requirements in the query formulation put to the underlying DR system can be used to increase recall or precision or both. Local screening cannot retrieve documents missed in the underlying search, but it can increase the precision beyond that achieved in the underlying search.

- (2) Improve the display of retrieval results and allow the user to customize it to better support the user's own information processing.

Application of these ideas might be particularly useful for what is now commonly called "information filtering," namely retrieving at regular intervals, from an incoming stream of documents, those that are of potential interest to a user and presenting the retrieved documents in a sequence that supports final screening by the user.

The incorporation of additional, particularly nontopical, selection rules into a retrieval algorithm, such as ranking a document higher on account of the standing of the author or journal could improve retrieval performance significantly yet is fairly straightforward, provided the knowledge needed is available (see below).

Some principles emerged from the presentation of document records to support the user's own selection. There are three design elements: the sequence of document records in the retrieved set, the presentation structure of the individual record (what Document Information Elements are included, in what sequence, with what emphasis), and the presentation of options for categorizing documents by their relation to the query and anticipated use.

Overall Sequence of Presentation of Documents. Arrange documents into meaningful groups; document groups that are chained together should be presented to-

TABLE 9. Comparison of DIES examined in four relevance studies.

Wang (1994)	Barry (1993)	Park (1992)	Janes (1991)
Title	+	+	+
Abstract	+	+	+
Descriptor	+	+	+
Geographic location			
Author/editor	+	+	+
Author/editor's affiliation	+	+	
Publisher/agency	+		
Journal	+	+	+
Publication date	+	+	+
Document type	+	+	
Document length	+		
Volume and issue			
Language			
Media			
Subfile			
Edition			
Author's expertise*			
Table of contents*			
Citation status* (being cited?)			
	Full text (body, notes, tables, graphs, references)		

* The DIES were not in bibliographic citations and mentioned by some users as needed for making a decision. Author's expertise was often drawn on personal knowledge.

gether (relevant decision rules: chain, dominance, scarcity, satisfice). Adjust the sequence dynamically based on user feedback.

Presentation Structure of Document Records. There are three devices that can be applied in the design of the presentation structure: selection of the DIES to be displayed, sequence of the DIES, and emphasis/highlighting of important DIES. Both selection and sequencing of DIES could be varied from record, depending on the sequence in which the user is expected to attend to the DIES; this sequence depends on the specific values of DIES, especially author and journal. However, such changes from record to record might be confusing for the user. Perhaps it would be better to always display the DIES most often used by this user in the sequence preferred by this user and to highlight the DIES that are expected to be important for the selection decision for the document at hand. In particular, DIES that support immediate rejection should be highlighted. An additional group of DIES—those next in frequency of use by this user—should be presented either on the user's request or after the user spends more than a given amount of time looking at a document record.

Presentation of Options for Categorization. Users perception of the possible use of a document may be in many different ways, and there are underlying reasons for a selection decision. Reasons for selection are manifested in the values of the criteria, *topicality*, *quality*, *relation*, etc. Soliciting these reasons for selection would be helpful in later stages of document retrieval and might

also serve to sharpen the user's thinking about document selection. Thus, the interface should prompt the user with a menu of relationships between the document and the need as well as anticipated document uses; the response from the users should be stored in a knowledge base as an integral part of the DR system.

The user should be able to enter some rules for selection of DIES in each record and for their order of presentation and/or highlighting within the record (highlighting important DIES may be better than varying the sequence from record to record). Rules might include, for example: to normally highlight the title, but if author or journal are on the preferred list, highlight them. The order of presentation has two aspects: simultaneous presentation in a given arrangement, or actually adding the DIES to the presentation later.

To apply the selection criteria that emerged from our study, an DR system needs a knowledge base that replicates the user's knowledge about persons and organizations, journals and other document sources, and topics. This knowledge can be assembled from several sources: public sources, knowledge shared within a work group or between an advisor and a student, personal knowledge (particularly personal evaluative knowledge) input explicitly by the user, and learning by the system from relevance feedback. A knowledge base constructed in a systematic fashion would extend the user's limited experience and memory. Key components of such a knowledge base are:

Knowledge about Persons and Organizations. Discipline (from public sources). Quality/authority (from public sources, such as receiving prizes or publications

receiving prizes, or institutional affiliation, citation data; probably more from user). Relationship to user (advisor, former colleague, potential referee of the paper or proposal the user is working on).

Knowledge about Journals and Other Sources of Documents. Quality (from public sources, such as published rankings, citation counts; user input). Availability (providing links with local catalogs, remote sources, or full text).

Topics. Relationship between topics. Facets of a topic. Terminology that indicates a topic or a particular facet. Obsolescence rate in a given topic area, when did the topic start. Seminal papers for topics.

The system could learn from *differentiated relevance feedback*: as he/she goes through document records, the user puts the cursor on the element most responsible for the decision (author, title, etc.) and clicks the left for accept or right for reject. (Documents not clicked on at all are considered rejected.) If all documents by a given author are rejected, the system would infer that, for the query at hand, documents by that author are not useful; the system should amend its knowledge base about authors, after asking the user explicitly about that author. The user would also indicate the reason for acceptance and rejection as discussed above. The system could use statistical analysis to identify document cues associated with the various reasons and for further documents suggest a selection reason as the default. This differentiated relevance feedback could also be used to adjust retrieval, including the launching of targeted additional searches, thus modifying the unexamined part of the retrieved list, and to adjust the presentation of document records. With a voice input/output device for IR systems, this human computer interaction about relevance feedback will be more effective and efficient.

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