

User Perceptions of Uncertainty in the Evaluation of Search Results

Yang-woo Kim*

Division of Knowledge & Information, Hansung University,
389 Samsun-dong 3-ga, Sungbuk-gu, Seoul,
Republic of Korea, 136-792

ABSTRACT

While considerable research suggests that users' uncertainty gradually decreases, as they proceed through the information seeking process, others argue that it can arise at any stage of their information seeking process. Reflecting the latter view, this study examined user perceptions of uncertainty in the final stage of users' information seeking process, **the stage of search results evaluation**. Considering the significance of Web search engines for academic study, this study investigated the relevance decision stage of scholarly researchers in the field of science, who use Web search engines for their academic study. Based on the analysis of the users' uncertainty, this study provided implications to improve information systems and Web contents design.

Keywords: Web Contents Design; Relevance; Uncertainty; Information Education; Information System; Interdisciplinary Studies

1. INTRODUCTION

Uncertainty is an essential concept within human information behavior (HIB) research. Researchers in general suggest that the information seeking process begins with uncertainty but as the user proceeds through the information seeking and retrieval process, uncertainty gradually decreases [1], [2]. Wilson, Ellis, Ford, and Spink agree with this view but they also argue that at any of the four stages, i.e. problem recognition, problem definition, problem solution, and solution statement, uncertainty may arise [3]-[5]. Reflecting the latter view (Wilson et al.'s), the present study investigated user perceptions of uncertainty in the final stage of users' information seeking process, that is *the stage of search results evaluation*.

A variety of Web search engines have become essential tools for retrieving both academic and non-academic information. Considering the importance of Web search engines for academic research, this study investigated the *relevance decision stage* of scholarly researchers, particularly at the doctoral or post-doctoral level, who use Web search engines for their academic study. The participants were from the discipline of science as an attempt to understand user perceptions in this field. The identification of the different uncertainties yielded implications to improve information systems and Web contents design.

2. LITERATURE REVIEW

A few studies investigated user perceptions of uncertainty, yet in different stages from the stage of *results evaluation* as the present study does. Those different stages include the selection of information systems [6] and the selection of search terms [7]. Earlier than this, a number of research examined user uncertainty in results evaluation: difficulty in determining the usefulness of documents [8], particularly as a concrete binary judgment [9]-[11]. Yet these studies did not deal with use of Web search engines for academic purposes.

More recently, a significant body of work has been done with respect to user uncertainty in different aspects of information seeking and retrieval. Those include: three types of uncertainty related to knowledge deficiency – indeterminacy, ignorance, and incommensurability [12]; positive uncertainty to generate creativity [13]; correlations among information seeking activities and information seeking problems that cause uncertainty [14]; the effects of physicians' attitudes toward uncertainty on their use of electronic information resources [15]; use of online tutorials to reduce uncertainty in information seeking behavior [16]; a review of the literature with a focus on emotion (i.e., uncertainty) of healthcare professionals [17]; uncertainty of work task in stage-driven information seeking process [18]; uncertainty in the virtual playground of generation Y students [19]; information seeking activities and information seeking problem as the causes of uncertainty [20]; the effects of task uncertainty on the scope of external information seeking [21]; three different types (task,

* Corresponding author. E-mail : ykim@hansung.ac.kr
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technical and strategic) of uncertainty in psychologists' research activities[22].

While the above studies present both theoretical and practical discussions related to uncertainty, less attention has been paid to perceptions of uncertainty by end-users who are engaged in an actual search process with a real information system. This is particularly true in examining uncertainty for the *relevance judgments of search results*.

3. RESEARCH METHOD

Using grounded theory approach [23], [24], this study examined the users' information-seeking process for academic purposes. A grounded theory is one that is inductively derived from the study of the phenomenon it represents. That is, it is discovered, developed, and provisionally verified through systematic data collection and analysis of data pertaining to that phenomenon. Therefore, in this approach one does not begin with a theory, then prove it. Rather, one begins with an area of study and what is relevant to that area is allowed to emerge.

Based on theoretical sampling method, thirty subjects from a university in Canada participated in this study. This study followed a qualitative study approach for the collection and analysis of data based on grounded theory. In general, it is stated that a qualitative approach is appropriate when the data has a subjective nature associated with indeterminate processes, particularly in the context of human information behavior [25].

For the collection of data, each subject was asked to fill in a questionnaire and participate in a subsequent interview. Then, for the analysis of data, the subjects' responses were coded and grouped, characterizing various aspects of uncertainty.

The coefficients of reliability [26] were computed in order to measure inter-coder agreement between the author and two independent coders recruited. The formula used is $C.R. = 2M / (N1 + N2)$, where M is the number of coding decisions on which the author and a coder are in agreement, and N1 and N2 refer to the number of coding decisions made by them. The reliability measures reached an "acceptable" [27] level with the ratio of .83 and .86, respectively.

4. RESULTS

Data analysis led to the identification of three dimensions of uncertainty and seven different types of uncertainty, for a total of 30 incidents. The types of uncertainty assigned to the dimensions are shown in Table 1, with the number of incidents of uncertainty in each type and one or two examples of incidents for each type. Each incident is accompanied by the subjects' corresponding descriptions. In addition, definitions

of each type and a list of all incidents of uncertainty are shown in Tables 2 and 3, respectively.

The concepts of topicality and non-topicality were adopted to categorize the types of uncertainty in this information seeking phase. Several researchers conducted empirical studies emphasizing the significant role of non-topicality as well as topicality in people's relevance judgments [56-59]. In addition, numerous studies in the interdisciplinary areas have discussed non-topicality or beyond-topicality in varying domains and terminologies. A generally accepted definition of the non-topicality concept includes: (1) non-subject attributes that characterize users' needs or documents (i.e., specificity of information; degree of difficulty; level of scientificness; point of view; research methodology employed; form or type of document); and (2) characteristics of prospective readers of documents (i.e., educational level, age level).

The three dimensions of uncertainty identified in the results evaluation phase were: *topicality*, *non-topicality*, and *topicality & non-topicality*. The first dimension, *topicality*, concerned the subject matter of retrieved items or user needs. The type of uncertainty identified within this dimension was *topical relevance*, which concerned subject-based relatedness and usefulness of documents to user needs (see Tables 1, 2, and 3). The nine incidents of uncertainty categorized into this type included:

- *topical relevance – disciplinary area* (S002, S020);
- *topical relevance – sub-topicality* (S002, S004, S011, S026, S028);
- *topical relevance – different aspect of the topic* (S008); and
- *topical relevance – inappropriate granularity of the topic* (S013) (see Table 3).

For example, Subject 013 indicated uncertainty in *topical relevance – inappropriate granularity of the topic* by the following response:

"It's not specifically related to my immediate research, but it looks more generally related, dealing with more general topics.... I don't know if I'd print it or not" (see Table 1).

The second dimension, *non-topicality*, encompassed non-subject attributes that characterized users' needs or documents (i.e., availability of information, degree of details, research methodology employed, and form or type of document). Four types of uncertainty identified within this dimension were *accessibility of information object*, *timeliness of information*, *length of information object* and *expertise of information available*

Table 1. Uncertainty in Evaluating the Usefulness of Search Results

Dimension of Uncertainty	Types of Uncertainty	No. of Incidents	Example of Incident of Uncertainty	Subjects' Descriptions (Subject # – Instrument)

Topicality	Topical relevance	9	Topical relevance – inappropriate granularity of the topic	“It’s not specifically related to my immediate research, but it looks more generally related, dealing with more general topics. I don’t know if I’d print it or not.” (S013 – T)
Non-topicality	Accessibility of information object	4	Accessibility of a physical object located	“I am not sure whether this chemical (‘pectinase’) will be available. If this chemical is a new chemical from this lab, it will be a little bit difficult to obtain. I will check the protein catalog and chemical catalog.” (S001– T)
	Timeliness of information	2	Currency of information	“I am not sure this content is very current. Perhaps I need to check with someone.” (S030 – T)
	Length of information object	3	Length of the site	“This site is rather short, without sufficient links. Not sure how much this is going to help me.”(S022 – T)
	Expertise of information available	3	Expertise in the site content	“This site doesn’t seem to have sufficient expertise. I am not sure whether I am going to use it.”(S021– T)
Topicality & non-topicality	Relevance dilemma – utility	6	Utility – topicality (P); degree of details (N)	“This site is topically related but does not have details. I am not sure at this moment whether I will use this.” (S003 – T)
			Utility – topicality (P); source credibility (N)	“You can get useful information about arteriosclerosis and the use of antioxidants to prevent the progress, progression of this disease.... So this could be useful for my research. But there is some uncertainty here because I have never heard of Mambir Online before and I don’t know how credible this site would be and so I would feel hesitant referencing it if I would get some information from this site.” (S005 – T)
			Utility – topicality (P); currency (N)	“This site is certainly topic-related, yet rather outdated.” (S023 – T)
	Relevance dilemma – time efficiency	3	Time efficiency – topicality (P); organization of site (N)	“This site certainly discusses about computational geometry, but it has too many links and too much information. It did not prioritize or limit scope. It has no rank. I am not sure whether I will use this. I need to consider time limitations also.” (S003 – T)
Time efficiency – topicality (P); degree of details (N)			“This site contains interesting information about the antioxidants.... But it seems to me that there’s quite a big number of antioxidants that could be used. And in order to screen out these for experiments in my research, it wouldn’t be time-efficient because I have limited time, so I’m not sure whether I can effectively use the information of this web site.” (S005 – T)	
Total		30		

Note. P = Positive relevance factor; N = Negative relevance factor; Instrument = Data Collection Instrument; T = Think-aloud; Relevance dilemma = Conflict between a positive relevance factor and a negative relevance factor

Table 2. Uncertainty in Evaluating the Usefulness of Search Results: Definition of Types

Dimension I. Topicality	
Types of uncertainty	Definitions
Topical relevance	Subject-based relatedness/usefulness of documents to user needs
Dimension II. Non-topicality	
Types of uncertainty	Definitions

Accessibility of information object	Availability of information object
Timeliness of information	Currency of information contents
Length of information object	Length of contents in the located site
Expertise of information available	Special skill or knowledge shown in the information object

Dimension III. Topicality & Non-topicality

Types of uncertainty	Definitions
Relevance dilemma – utility	A situation in which an uncertainty in determining the utility of a retrieved site occurs because of a conflict between the contrasting characteristics of the retrieved site
Relevance dilemma – time efficiency	A situation in which an uncertainty in determining the time efficiency of using a retrieved site occurs because of a conflict between the contrasting characteristics of the retrieved site

Table 3. Uncertainty in Evaluating the Usefulness of Search Results: Incidents for Each Type

Dimension I. Topicality

<p>Type – Topical relevance (9) Topical relevance – disciplinary area (S002, S020) Topical relevance – sub-topicality (S002, S004, S011,026, S028) Topical relevance – different aspect of the topic (S008) Topical relevance – inappropriate granularity of the topic (S013)</p>

Dimension II. Non-topicality

<p>Type – Accessibility of information object (4) Accessibility of a physical object located (S001, S024) Accessibility of a specific resource type – research reports (S006) Cost for access (S012)</p>
<p>Type – Timeliness of information (2) Currency of information (S019, S030)</p>
<p>Type – Length of information object (3) Length of the site (S022, S024, S025)</p>
<p>Type – Expertise of information available (3) Expertise in the site content (S021, S028, S029)</p>

Dimension III. Topicality & Non-topicality

<p>Type – Relevance dilemma – utility (6) Utility – topicality (P); format-figure, table (N) (S001) Utility – topicality (P); degree of details (N) (S003) Utility – topicality (P); source credibility (N) (S005) Utility – topicality (P); source credibility (P); format-equation (N) (S007) Utility – topicality (P); currency (N) (S021, S023)</p>
<p>Type – Relevance dilemma – time efficiency (3) Time efficiency – topicality (P); organization of site (N) (S003, S019) Time efficiency – topicality (P); degree of details (N) (S005)</p>

Note. Number of incidents for each type is in parentheses. Subject number for each incident is in parentheses.

(see Tables 1, 2, and 3).

The type of uncertainty *accessibility of information object* concerned the availability of information objects (see Table 2). The four incidents of uncertainty categorized into this type included:

- *accessibility of a physical object located* (S001, S024);

- *accessibility of a specific resource type – research reports* (S006); and
- *cost for access* (S012) (see Table 3).

For example, Subject 001 indicated uncertainty in *accessibility of a physical object located* by the following response:

“I am not sure whether this chemical (‘pectinase’) will be available. If this chemical is a new chemical from this

lab, it will be a little bit difficult to obtain. I will check the protein catalog and chemical catalog” (see Table 1).

This particular incident of uncertainty related to relevance judgments in the phase of information use beyond the searching process. Interestingly, a relevance judgment, which evaluated the usefulness of a particular document, was influenced by the prediction of prospective availability beyond the text content evaluation.

The type of uncertainty *timeliness of information* concerned currency of information contents (see Table 2).

The two incidents of uncertainty categorized into this type included:

- *currency of information* (S019, S030).

For example, Subject 030 indicated uncertainty in the *currency of information* by the following response:

“I am not sure this content is very current.” (see Table 1).

The type of uncertainty *length of information object* concerned length of contents in the located site (see Table 2).

The three incidents of uncertainty categorized into this type included:

- *Length of the site* (S022, S024, S025);

For example, Subject 022 indicated uncertainty in the *length of the site* by the following response:

“This site is rather short, without sufficient links. Not sure how much this is going to help me.” (see Table 1).

The type of uncertainty *expertise of information available* concerned special skill or knowledge shown in the information object (see Table 2).

The three incidents of uncertainty categorized into this type included:

- *Expertise in the site content* (S021, S028, S029);

For example, Subject 021 indicated uncertainty in the *expertise in the site content* by the following response:

“This site doesn’t seem to have sufficient expertise. I am not sure whether I am going to use it.”

The third dimension, *topicality & non-topicality*, included types of uncertainty that related to both topical and non-topical aspects of users’ needs or retrieved sites. Some of the incidents of uncertainty identified in the results evaluation phase were accompanied by more than one characteristic of the retrieved sites, which influenced the subjects’ relevance judgments. Such incidents of uncertainty related to a conflict between the contrasting characteristics of the retrieved sites. These incidents were coded as *relevance dilemma* and assigned to the dimension of *topicality & non-topicality* because the conflicting characteristics concerned both topical and non-topical aspects of the information seeking process.

Relevance dilemma referred to a situation in which an incident of uncertainty about the relevance judgment occurred because of a conflict between a positive relevance factor and a negative relevance factor. A positive relevance factor specified a characteristic of the retrieved item which favorably influenced a user’s judgment; a negative relevance factor pointed out one that unfavorably affected it. For example, a located site contained information related to one subject’s (Subject 005) topical need while being uncertain about the credibility of its source:

“As far as I can see from this site, you can get useful information about arteriosclerosis.... But there is some uncertainty here because I have never heard of Mambir Online before and I don’t know how credible this site would be, and so I would feel hesitant referencing it when I would get some information from this site.” (see Table 1).

For this particular incident, *topicality* was treated as a positive relevance factor (P), and *source credibility* was a non-topical attribute treated as a negative relevance factor (N).

Two different types of uncertainty identified within the third dimension were: *relevance dilemma – utility* and *relevance dilemma – time efficiency* (see Tables 1, 2, and 3). The type of uncertainty *relevance dilemma – utility* concerned a situation in which an uncertainty in determining the utility of a retrieved site occurred because of a conflict between the contrasting characteristics of the retrieved site (see Table 2). The three incidents of uncertainty categorized into this type included:

- *utility – topicality (P), format-figure, table (N)* (S001);
- *utility – topicality (P), degree of details (N)* (S003);
- *utility – topicality (P), source credibility (N)* (S005);
- *utility – topicality (P), source credibility (P) & format-equation (N)* (S007) and
- *utility – topicality (P), currency (N)* (S021, S023); (see Table 3).

For example, Subject 003 indicated uncertainty in *utility – topicality (P), degree of details (N)* by the following response:

“This site is topically related but does not have details. I am not sure at this moment whether I will use this” (see Table 1).

The type of uncertainty *relevance dilemma – time efficiency* concerned a situation in which an uncertainty in determining the time efficiency of using a retrieved site occurred because of a conflict between the contrary characteristics of the retrieved site (see Table 2). The three incidents of uncertainty categorized into this type included:

- *time efficiency – topicality (P), organization of site (N)* (S003, S019); and
- *time efficiency – topicality (P), degree of details (N)* (S005) (see Table 3).

For example, Subject 003 indicated uncertainty in *time efficiency – topicality (P), organization of site (N)* by the following response:

“This site certainly discusses computational geometry, but it has too many links and too much information. It did not prioritize or limit scope. It has no rank. I am not sure whether I will use this. I need to consider time limitations also” (see Table 1).

5. DISCUSSION

The information seeking context of individuals concerns a number of related components such as information needs, information systems, and resources of information systems. The incidents of uncertainty identified in the results evaluation phase reflected the subjects' perceptions as mainly related to the first and third components: information needs and resources of information systems. Accordingly, in this information seeking phase, the following were noted as the components that characterized the users' information seeking context: the needs of scholarly researchers in the area of science; and World Wide Web sites as information resources.

This section has following two subsections. The first subsection, 5.1, discusses exemplary incidents of uncertainty in relation to the subjects' information seeking context. The

next subsection, 5.2, addresses the usefulness of the typology of uncertainty for understanding the subjects' uncertainty and their information seeking context.

5.1 Uncertainty and Understanding the Information Seeking Context

The analysis of uncertainty in the process of information seeking offers an understanding of the information-seeking context of individuals. As indicated, the

Table 4. Uncertainty and the Information Seeking Context – Results Evaluation

Uncertainty		Information seeking context
Exemplary incidents	Subjects' descriptions (Subject # – Instrument)	Related characteristics of WWW sites
Utility – topicality (P); source credibility (N)	“You can get <u>useful information about arteriosclerosis</u> and the use of antioxidants to prevent the progress, progression of this disease.... So this could be useful for my research. <u>But there is some uncertainty here because I have never heard of Mambir Online before and I don't know how credible this site would be and so I would feel hesitant referencing it if I would get some information from this site.</u> (S005– T)	Insufficient quality control mechanism for WWW resource – source credibility
Time efficiency – topicality (P); organization of site (N)	“This site <u>certainly discusses computational geometry, but it has too many links and too much information. It did not prioritize or limit scope.</u> It has no rank. <u>I am not sure whether I will use this.</u> I need to consider <u>time limitation also.</u> ” (S003 – T)	An excessive number of outgoing links

Note. P = Positive relevance factor; N = Negative relevance factor; Instrument = Data Collection Instrument; T = Think-aloud

incidents of uncertainty identified in *the results evaluation phase* reflected the subjects' perceptions as mostly related to users' information needs and information resources. Accordingly, the incidents of uncertainty identified in this phase facilitated an understanding of the researchers' needs and Web resources.

Among the uncertainties identified, some incidents can apply to other information seeking contexts, not only the context investigated in this study. For example, Subject 013 expressed uncertainty in *topical relevance – inappropriate granularity of the topic*, in the following response:

“It's not specifically related to my immediate research but it looks more generally related, dealing with more general topics.... I don't know if I'd print it or not.”

Such an incident of uncertainty could apply to other information seeking contexts that concerned different user groups or information resources. This particular incident of uncertainty suggested that Subject 013 experienced uncertainty

about the topical relevance of a resource, which could also occur in other information seeking contexts.

Some incidents of uncertainty in this information seeking phase differentiate the information seeking context examined in this study from other contexts. Two exemplary incidents of such uncertainties are presented in Table 4.

In the first incident, Subject 005 indicated uncertainty in the *source credibility* of a retrieved item by the following response: “I have never heard of Mambir Online before and I don't know how credible this site would be, and so I would feel hesitant referencing it.”

This particular incident can be explained by the insufficient quality control mechanism for World Wide Web resources as it relates to the source credibility of the resources (see Table 4).

In the second incident, Subject 003 indicated uncertainty in the *time efficiency* of using a retrieved item by the following response:

“It has too many links.... It did not prioritize or limit scope.... I am not sure whether I will use this. I need to consider time limitations also.”

This particular incident was influenced by the excessive number of outgoing links in a Web site. Many WWW sites have a considerable number of outgoing links while documents stored in other information systems (i.e., journal databases or printed resources) do not (see Table 4).

The incidents of uncertainty identified in *the results evaluation phase* provided insights into the users' information seeking context especially about their needs and information resources. The findings revealed variations in different incidents of uncertainty with respect to how they relate to the unique characteristics of the information seeking context. As indicated, some incidents more explicitly differentiated the information seeking context investigated in this study from other such contexts.

5.2 Types of Uncertainty and Facilitation of Understanding the Information Seeking Context

Identifying dimensions and types of uncertainty in this study supported an understanding of the users' uncertainty, thereby providing insights into their information seeking context. Both dimensions and types characterized the specific aspects of the users or the information systems and resources used.

In the results evaluation phase, the dimensions and types identified particularly facilitated an understanding of the users' needs and information resources among the different components of the information seeking context. The typology in this phase was useful in identifying various *aspects* of the users' uncertainty as related to the scholarly researchers' needs in the area of science and located World Wide Web sites.

As discussed, the analysis of uncertainty in *the results evaluation phase* identified three dimensions of uncertainty about different *aspects* of the information seeking process: *topicality* concerning the subject matter of users' needs or retrieved resources; *non-topicality* concerning non-subject attributes that characterize users' needs or retrieved resources; and *topicality & non-topicality* concerning both topical and non-topical aspects of users' needs or retrieved resources.

The types of uncertainty within each dimension indicated that the subjects experienced uncertainty in various aspects of the information seeking process. For example, the type of uncertainty within the first dimension (*topicality*) was *topical relevance*, which concerned the subject-based relatedness or usefulness of the resources to users' needs (see Tables 1, 2, and 3).

The types of uncertainty identified within the second dimension (*non-topicality*) revealed more diverse aspects of the information seeking process. Different aspects that constituted the users' uncertainty in each type were: availability of information objects, as revealed in the type of uncertainty *accessibility of information object*; currency of information contents, as revealed in the type of uncertainty *timeliness of information* and so on (see Tables 1, 2, and 3).

The types of uncertainty assigned to the third dimension (*topicality & non-topicality*) included

relevance dilemma – utility and *relevance dilemma – time efficiency* (see Tables 1 and 3). Different aspects that constituted the users' uncertainty in each type were: the overall utility of a retrieved site, as revealed in the type of uncertainty *relevance dilemma – utility*; and the time efficiency of using a retrieved site, as revealed in the type of uncertainty *relevance dilemma – time efficiency* (see Tables 1, 2, and 3).

As addressed above, the typology of uncertainty helped to identify the different aspects of the information seeking process that constituted the users' uncertainty. The identification of those aspects facilitated an understanding of the users' information seeking context, which concerned varying components in different information seeking phases.

6. CONCLUSION

The identification of uncertainty in this study was useful for yielding implications to improve information systems and Web contents design. Among others, an insufficient quality control mechanism for World Wide Web resources and an excessive number of outgoing links were major components that cause the users' uncertainty. This suggests that Web contents providers need to be careful with respect to source credibility and optimal length of each site.

Different information-seeking contexts concerning other related components than researchers in science, Web search engines, and World Wide Web sites would constitute further research environment. Perhaps, researchers in humanities and social sciences would plausible research subjects, possibly using different information systems such as formal journal databases.

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Yang-woo Kim

He received the B.S. in Business Management from University of Maryland, Asian Division, Korea in 1991 and M.S. in Library and Information Science from Emporia State University, USA in 1998. He also received Ph.D. in information science from Rutgers University, USA in 2004. Since 2005, he has been with Division of Knowledge and Information, Hansung University. His main research interests include information seeking behavior and Web contents development.