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A PRINCIPLE OF UNCERTAINTY FOR INFORMATION SEEKING

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This paper proposes an uncertainty principle for information seeking. The principle is based on the results of a series of studies conducted by the author into the user's perspective of the information search process. A basic principle of uncertainty is elaborated by six corollaries. The principle is proposed to explain the constructive process of information seeking and use bringing affective considerations to what has usually been regarded as a cognitive process.

INTRODUCTION

LIBRARY AND INFORMATION STUDIES are in a theory building phase. Traditional conceptual frameworks are being re-examined and new perspectives are being proposed. Some of the most interesting current research is converging around investigation into the user's perspective of information seeking. This paper discusses constructivist theory as a conceptual framework for studying the user's perspective, bringing affective considerations to what has usually been regarded as a cognitive process. Methods for investigating users in actual situations of information seeking are described with examples from the author's research into this area. An uncertainty principle as a theoretical position is proposed which is grounded in research in the information search process. In conclusion, some promising directions for future research are discussed.

2. INFORMATION SEEKING AS A CONSTRUCTIVE PROCESS

Within the past few years there has been a noticeable shift in the conceptual approach to information studies to the user's perspective of information seeking and use. In 1986, Dervin and Nilan in a review of research into

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information needs and uses found that most studies remain constrained by the system's definition of needs with the menu of responses coming from the system's view of the world and not the user's [1]. They called for research within a new paradigm of the user's perspective in order to provide a solid research base on which to build a conceptual framework for both practice and research. Others have substantiated that research is needed which goes beyond the study of seeking and gathering of information to the study of the constructive process of using information to solve the problem which initiated the information need [2–5].

Although there have been relatively few empirical studies of users' problems and processes, some important work has been done which indicates a direction for further investigation. Taylor's [6] levels of information need (visceral, conscious, formal and compromised), Belkin [7, 8] and his colleagues' work on the ASK hypothesis (anomalous state of knowledge), Dervin's [9] studies of sensemaking, and Saracevic's [10] description of relevance are some examples of this work. Also investigation of search techniques, procedures and strategies which accommodate the user's perspective have opened a productive line of research [11–15].

My own work has investigated the experience of users within the levels or stages of the information search process as they move from ambiguity to specificity, or what I call uncertainty to understanding [16].

3. BORROWING A CONSTRUCTIVIST FRAMEWORK OF LEARNING

The constructivist view of learning has provided a particularly fruitful, theoretical framework for my own research into the information search process. This framework is purposefully applied to explain the role of information in the individual's process of problem solving or finding new ideas, involving such important mental steps as the production of hypotheses. The framework extends the ASK hypothesis of Belkin and other dynamic but step-like theoretical constructions.

The work of three prominent theorists on construction, John Dewey, George Kelly and Jerome Bruner, has formed the conceptual basis. Dewey [17] provides the philosophical foundation for viewing learning as a constructive process. Kelly [18], a clinical psychologist, verified and refined the theory from the psychological perspective. Psychologist Jerome Bruner [19] further verified constructive theory in his research on perception. His recent writings offer a contemporary perspective on learning as a constructive process [20].

Each of these theorists contributed to a conceptual perspective which provided a lens for viewing and interpreting data collected on users' experience in information seeking. Dewey describes the dynamic role that the individual plays in the process of using information for learning. He reveals that deep thinking and reflection are an integral part of the constructive process.

If we knew just what the difficulty was and where it lay the job of reflection would be much easier than it is. . . . As the saying goes, a question well put is half answered. In fact, we know what the problem exactly is simultaneously with finding a way out and getting it resolved. Problem and solution stand out completely at the same time. Up to that point, our grasp of the problem has been more or less vague and tentative [17, p.108].

3.1 Dewey's Phases of Reflection

Dewey described what he called reflective thinking as occurring in five phases: *suggestion, intellectualisation, guiding idea or hypothesis, reasoning, and testing by action* [17, pp. 106–114].

The first phase involves *suggestion*. In this phase a state of doubt due to an incomplete situation causes perplexity, confusion, uncertainty and hesitation. The second phase is *intellectualisation*. This involves conceptualising the problem, interpreting the given elements and anticipating possible solutions. The third is the phase of the *guiding idea or hypothesis*. A guiding idea is a tentative interpretation of the initial suggestion used as a hypothesis to initiate and guide the collection of factual material. A careful survey incorporating examination, inspection, exploration and analysis is made to define and clarify the problem at hand. Acts of searching, hunting and inquiring to find information characterise this phase. The fourth phase is one of *reasoning*. The hypothesis is made more precise and more consistent by familiarity with a wider range of facts. An elaboration of the idea emerges through reasoning. The fifth phase, *testing by action*, involves taking a stand on the tentative hypothesis, doing something to bring about results to test the hypothesis in order to resolve the doubt and perplexity. The idea may be tested by either overt or imaginative action.

3.2 Kelly's Phases of Construction

Some years later, George Kelly [18] described the process of forming new constructs as progressing through a series of psychological phases. His descriptions of experience in the phases of construction are strikingly similar to Dewey's stages of reflective thinking. Kelly, however, expanded on Dewey's model by emphasising the disruptive impact of new information to a person's system of constructs and the resulting increase in uncertainty in the early phases of the process of construction.

Kelly also explains the process of construction in five phases. The first phase is initiated by a new experience or a vague new idea which cannot be assimilated into the existing system of constructs characterised by feelings of confusion and doubt. In the second phase, the sense of confusion and uncertainty increases and may become quite threatening when further new information is inconsistent and incompatible with existing constructs. The third phase is the turning point in the process when the new idea is either rejected or a tentative hypothesis is formed to provide a direction to pursue. In the fourth phase the hypothesis enables one to 'break through his moment of

threat to get on with the task of testing to confirm or reject the hypothesis' [21, p. 151]. The final phase of the cycle involves assessing the outcome and reconstruing and assimilating the new construct.

3.3 Bruner's Phases of Interpretation

Bruner's research and writing corroborates and elaborates the active part the individual plays in the constructive processes of both Dewey and Kelly. Similar to Dewey's reflection and Kelly's reconstruing, Bruner emphasises the task of interpreting as being central to construction. Merely gathering information is not enough. Bruner explains that:

If we are to understand it (a new idea), it will not be by means of a positivist archaeology in which everything particular about it and everything leading up to it are finally dug up, labelled and collated. However much we dig and delve, there is still an interpretive task [20, p. 53].

The interpretive task begins with perception when a person first encounters new information. The second phase involves selecting a process of recognising patterns and the third phase involves making inferences by joining clusters and connecting categories. From the selection and inference, predictions are made in the fourth phase, what Bruner refers to as 'going beyond the information given'. The interpretive task is completed by action in the final phase that results in the creation of products of the mind.

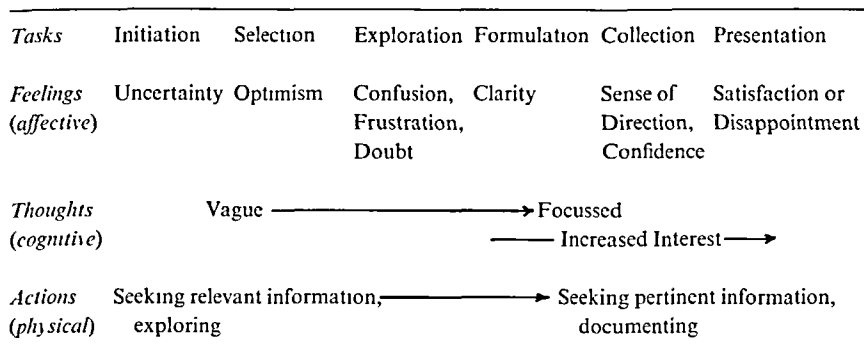
These descriptions of the constructive process in general provided a conceptual assumption for studying information seeking as a process of construction in my own research.

4. EMPIRICAL TESTING OF A BORROWED CONCEPTUAL FRAMEWORK

A borrowed theory needs to be tested within the context of information seeking in order to be established as a grounded conceptual perspective. Using the premise that an individual is actively involved in his or her progression from uncertainty to understanding, the hypothesis was formed and tested that information seeking is a process of construction experienced in phases similar to those described by Dewey, Kelly and Bruner. In a series of five studies of information seeking and use from the user's perspective, a model of the information search process was developed [22–26].

4.1 The information search process

The studies revealed common patterns in the users' experience in the information search process that may be described in a series of phases or stages: *initiation*, *selection*, *exploration*, *formulation*, *collection* and *presentation*. Each stage represents the task considered most appropriate to move the process on to the subsequent stage. The model of the information search process incorporates three realms of human experience: the affective (feelings), the cognitive (thoughts) and the physical (actions) within each stage, as shown in Figure 1.

FIGURE 1. *Model of the information search process*

At *initiation*, when a person first becomes aware of a lack of knowledge or understanding, feelings of uncertainty and apprehension are common. At this point, the task is merely to recognise a need for information. Thoughts are vague and ambiguous centring on the general problem or area of uncertainty.

Selection is the second stage when the task is to identify and select the general area or topic to be investigated or the approach to be pursued. Feelings of uncertainty often give way to a brief sense of optimism after a selection has been made and there is a readiness to begin the search. Thoughts centre on weighing prospective topics against the criteria of personal interest, assignment requirements, information available and time allotted. The outcome of each possible choice is predicted and the topic or approach judged to have the greatest potential for success selected. When, for whatever reason, selection is delayed or postponed, feelings of anxiety are likely to intensify until a choice is made. Actions often involve seeking background information on the general area of concern.

The next stage is *exploration*, which is often the most difficult stage for users and the most misunderstood by intermediaries. Feelings of confusion, uncertainty and doubt frequently increase during this time. The task is to investigate information on the general problem in order to extend personal understanding. Thoughts centre on becoming oriented and sufficiently informed about the topic to form a focus or a personal point of view. At this stage an inability to express precisely what information is needed makes communication between the user and the system awkward. Actions involve locating information relevant to the general problem, reading to become informed and relating new information to what is already known. During the exploratory stage of information seeking, there are two types of uncertainty: one of a conceptual nature (i.e. what the user is looking for) and one related to the interactive technical process of retrieving information (i.e. how to make use of the search instruments, such as databases, interface options, commands, etc. in order to obtain conceptual information).

The fourth stage is *formulation* which is the turning point of the process

when feelings of uncertainty diminish and confidence begins to increase. The task is to form a focus from the information encountered in exploration. Thoughts become more clear and defined as a focussed perspective or point of view on the problem is formed.

The fifth stage is *collection* when interaction between the user and the system functions most effectively and efficiently. At this point, the task is to gather information pertinent to the focussed problem. Users have a clearer sense of direction, and can specify the need for particular information. Confidence continues to increase as uncertainty subsides with interest in the project deepening.

The sixth stage is *presentation* when the task is to complete the search and to resolve the problem. A sense of relief is common, with satisfaction if the search has gone well or disappointment if it has not. Thoughts centre on culminating the search with a personalised understanding of the problem.

The traditional conceptual framework for information seeking, the bibliographic paradigm, is based on certainty and order. A constructivist perspective, however, reveals that the early stages of information seeking commonly are fraught with uncertainty and confusion. A more holistic view of information seeking and use is needed incorporating the interaction of thinking, acting and feeling as users actually experience the process. Uncertainty and disorder as well as anxiety and apprehension may be expected in the early stages. A principle of uncertainty is indicated as an underlying conceptual framework for information retrieval and provision.

5. METHODOLOGY FOR BUILDING A NEW CONCEPTUAL FRAMEWORK

When information seeking is viewed as a process of construction, the user's experience becomes a critical component for analysis. Research based on a principle of uncertainty requires methods which elicit the user's perspective rather than that of the system. This is much easier said than done. Much of the traditional methodology in user studies has not been found to be appropriate for investigation of users' experiences in the process of information seeking. The shift of emphasis to users, and the holistic aspects of information use, require methods which reveal internal processes not readily measured by quantitative methods.

Building a new conceptual framework calls for a new approach to methodology. A combination of qualitative and quantitative methods needs to be applied to study various aspects of information needs and seeking over an extended period of time.

The research process is related to the information search process in that problems evolve through different stages of formulation. Research problems in early formative stages may be best addressed by qualitative methods to form testable hypotheses, which can then be measured and verified by more quantitative methods.

Qualitative and quantitative methods complement each other by offering two ways of looking at a problem. Qualitative methods offer an internal view,

which addresses the why of an issue, bringing insight to more quantitative findings. Qualitative methods offer ways to explore and investigate an obscure problem and to generate testable hypotheses. Quantitative methods offer ways to verify findings and to test hypotheses. Both methodologies need to be pursued rigorously and with an empirical approach. Both produce findings which lead to further research questions.

In my own work, the problem being addressed in each phase of research determined the methodology adopted. The sequence of research questions required both qualitative and quantitative methods. The methods and instruments developed in the initial study were adapted and refined to address further research questions in the subsequent studies. The series of five studies on the information search process have emerged into an area of research, theory and methodology which continues to open fruitful questions for further investigation, verification and refinement [27].

The sequence proceeded from a qualitative beginning which provided a hypothesis for further study in the form of a descriptive model. This was followed by large scale and longitudinal refinements and verification using both qualitative and quantitative methods. Then a conceptual perspective was formulated grounded in the context of information seeking. In order to build a theoretical framework it is necessary to go beyond reporting findings to making substantial statements of insight and principle.

6 EMERGENCE OF A CONCEPTUAL FRAMEWORK

This paper proposes a theory for information seeking based on the constructivist view of learning and grounded in the findings of the series of studies on the information search process of library users. The principle is based on the insight that information seeking may be viewed as a process of construction in which users progress from uncertainty to understanding.

Theory building is strengthened by expanding on a principle existing in the literature of the field. An uncertainty principle has been introduced into information science by several other researchers. Bates [28] recommends that uncertainty be used as one of the three design principles, the others being variety and complexity. The mechanistic assumption within the bibliographic paradigm is that there is an ideal indexing system with one perfect description of a document which will produce the best match with the user's information need and query. Bates maintains that the ideal is impossible in principle because of fundamental human traits which make indexing behaviour and information searching behaviour varied and individual. Therefore, a principle of uncertainty is posited to allow for the indeterminate range of mental associations which characterise human thought.

Whittemore and Yovits [29] also propose an uncertainty principle for the fundamental theory of information flow. They summarise the levels of communication research identified by Shannon and Weaver [30] by three questions:

What is the message?
What does the message mean?
What are the effects of the message on the recipient?

Concentrating on the third level, their research addresses the effectiveness and meaning of information to the user for decision-making, referred to as pragmatic information. Addressing the problem of the way information is used once it is transmitted and received, they set out to evaluate information in terms of the reduction of uncertainty for the decision-maker.

Uncertainty is the critical link between information and decision-making. To effect a meaningful analysis of pragmatic information, one must look in detail at that which makes decision-making such a challenging and oftentimes agonising activity: uncertainty [29, p. 224].

Yovits and Foulk found that uncertainty involved in decision-making enlivens learning and makes selection a dynamic process [31]. As understanding of the situation changes over time, attitudes toward uncertainty change as well. In the decision-making process confidence increases as the person obtains results which he or she predicts.

The confidence which the decision-maker has in his current model clearly affects the manner in which his state of knowledge is altered by the learning process and is an important factor in choosing a course of action [31, p. 64].

Testing the premise that information always reduces uncertainty, Yovits and his colleagues found that in some situations information may make a person more uncertain of his or her appraisal of a particular situation rather than less uncertain. They noted that typical decision models address those who are assumed to have reached a rather advanced state of knowledge about the decision situation in question. Information science, however, must cover all stages of decision-making, novel situations in which a sequence of related decisions is required over a period of time as well as advanced decision situations.

More recently, Ingwersen [4] has addressed the concept of uncertainty as inherent in the cognitive approach to information. The transformation of a problem space into a state of uncertainty is fundamental and takes place when a person cannot solve a problem or fulfil a goal by thinking [4, p. 28]. A state of uncertainty is defined as 'a state of doubt in which the individual's own state of knowledge, work space and cognition cannot fill the problem space by thinking, causing interaction with the world around it to obtain supplementary information, e.g. by accessing an IR system' [4, p. 131].

Both Sparck Jones [32] and van Rijsbergen [33] have pointed to the importance of uncertainty inherent in information retrieval. This paper specifies one of Sparck Jones' forms of uncertainty during information retrieval, the notion of the imprecise need [32, p. 9].

Building on the recognition of the importance of uncertainty introduced by these researchers, the emerging theory is further developed and articulated.

TABLE 1. *Uncertainty Principle*
 Uncertainty initiates the process of information seeking.

<i>Corollary</i>	<i>Definition</i>
Process	Constructing meaning and uncertainty
Formulation	Forming a focussed perspective
Redundancy	Encountering the expected and the unexpected
Mood	Assuming a posture or attitude
Prediction	Making choices based on expectations
Interest	Increasing intellectual engagement

Research into the users' actual experience in the process of using information for seeking meaning, gaining a deeper understanding and learning reveals pervasive patterns of uncertainty. Studies of the user's perspective of information seeking indicate an underlying persistence of uncertainty that shapes the way the process is commonly experienced. An uncertainty principle is proposed as a basic premise for information seeking and use.

7. UNCERTAINTY PRINCIPLE

Kelly's presentation of Personal Construct Theory offers a prototype for theory building which is composed of a fundamental postulate elaborated by a series of corollaries [18]. By adopting Kelly's prototype, an uncertainty principle is proposed based on the findings of the series of studies of the user's perspective of the information search process. The central principle, as a fundamental postulate, is supported and expanded by six corollaries which are also drawn from the findings of the studies, as shown in Table 1.

7.1 *The basic principle*

Uncertainty is a cognitive state which commonly causes affective symptoms of anxiety and lack of confidence. Uncertainty and anxiety can be expected in the early stages of the information search process. The affective symptoms of uncertainty, confusion and frustration are associated with vague, unclear thoughts about a topic or question. As knowledge states shift to more clearly focussed thoughts, a parallel shift occurs in feelings of increased confidence. Uncertainty due to a lack of understanding, a gap in meaning, or a limited construct initiates the process of information seeking.

The six corollaries are: *process corollary*, *formulation corollary*, *redundancy corollary*, *mood corollary*, *prediction corollary* and *interest corollary*. Each corollary will be presented as as a formal statement with discussion and less formal remarks following.

7.2 Process corollary

The process of information seeking involves construction in which the user actively pursues understanding and meaning from the information encountered over a period of time. The process is commonly experienced in a series of thoughts and feelings which shift from vague and anxious to clear and confident as the search progresses.

The active process of information seeking is experienced by users as a process of construction much the way the theorists described. Dewey's phases of reflective experience [17], Kelly's phases of construction [18], and Bruner's interpretive task [20] provide a theoretical basis for understanding individual experience in using information. People commonly experience a series of phases or stages as they seek information over an extended period of time. Within the stages of the information search process, people construct their own points of view or understanding of a topic or problem. The stages are experienced as an increase in understanding, interest and confidence from the initiation to the conclusion of the process.

The process involves the total person incorporating thinking, feeling and acting in the dynamic process of learning. From the user's point of view, information seeking is a holistic experience with thoughts, actions and feelings interwoven into a complex mosaic rather than as separate distinct entities. Thoughts unfold through actions and feelings evolve throughout.

The holistic process of information seeking has not been generally recognised in library and information studies. Within the traditional bibliographic paradigm attention has been given almost exclusively to actions with location as the central objective. Recently, more consideration has been given to the cognitive aspects of information use with thinking and interpretation as a goal. Incorporation of the affective, however, which is essential for fully understanding the experience of information seeking, has not yet occurred on any significant scale [5]. Information searching is traditionally portrayed as a systematic, orderly procedure rather than the uncertain, confusing process users commonly experience. After the search is completed, the topic understood and the problem solved, it is all too easy to look back and deny the chaos and confusion which was actually experienced in the process. Bruner [20] warns of a poverty bred by making too sharp a distinction between cognition, affect and action. Consideration of all three in unison offers new approaches and insights to long standing issues and problems in information retrieval and provision.

7.3 Formulation corollary

Formulation is thinking, developing an understanding, extending and defining a topic from the information encountered in a search. The formulation of a focus or a guiding idea is a critical, pivotal point in a search when a general topic becomes clearer and a particular perspective is formed as the user moves out of uncertainty to understanding.

The information search process involves not merely locating but using information with formulation as the central task in the process. Using

information involves interpreting and creating, what both Dewey and Bruner referred to as 'going beyond the information given'. The interpretive task, as Bruner [20] described it, is central to information seeking. No matter the amount or the quality of information gathered, the problem is not solved or the topic understood until the information has been interpreted. The user actively creates possible alternative ways to interpret information in the process of seeking information. This formulation is highly individual as there are many ways to view the world and many formulations which contribute to our collective understanding. There is no one way out of uncertainty but rather a multitude of individual constructions within the information search process.

The traditional approach to information seeking which promotes a single right answer to a specific question obscures the central task of the information search process, that of formulation for moving out of uncertainty to understanding in complex issues. Formulation, as the central task in the search process, is frequently misunderstood by users and mediators alike.

Users often find the period preceding formulation of a focussed perspective to be the most difficult in the search process. Uncertainty commonly increases during this time rather than gradually decreasing as one might expect. Users experience anxiety and frustration as they encounter conflicting and inconsistent information, much of which is not compatible with their own constructs. Some may be tempted to turn back and drop the quest altogether and we have no way of knowing just how many searches have been abandoned at this point. The connection between feelings and formulating is evident from the shift in increased confidence which parallels increased clarity as formulation unfolds.

Exploration is the key for formulating a focussed perspective during the search process. However, users often move directly from selecting a general topic or area to the task of collecting information, neglecting the important stage of exploration. Exploratory acts uncover information for formulating new constructs, whereas collecting acts gather information for documenting established constructs. Formulation of a focussed perspective moves the user out of uncertainty to understanding.

7.4 Redundancy corollary

The interplay of seeking what is expected or redundant and encountering what is unexpected or unique results in an underlying tension of the search process. Redundant information fits into what we already know and is promptly recognised as being relevant or not relevant. Unique information does not match our constructs and requires reconstruction to be recognised as useful. Redundancy may be expected to increase as uncertainty decreases. The lack of redundancy at the beginning of the search process may be an underlying cause of anxiety related to uncertainty.

The interplay of seeking what is expected or redundant on the one hand and encountering what is unexpected or unique on the other is little understood within the information search process. Redundancy in new information

confirms what we know. Uniqueness in new information extends what we know. The balance of redundancy and uniqueness is critical in a search for information. Too much redundancy results in boredom; too much uniqueness causes anxiety. The significant impact of emotion on the constructive process of information seeking is clearly illustrated by the problem of redundancy versus uniqueness encountered in a search. There is a distinct linkage between emotion and thinking which bears upon the actions we take and the choices we make.

The balance of redundancy and uniqueness shifts during the stages of the information search process. Early in the process the amount of uniqueness is likely to be much greater than later in the process. At the beginning, familiar information or redundancy is a reassuring sign that there is something that fits in with what we already know and that we are on the right track. Uncertainty and anxiety can be expected as a result of the large amount of uniqueness encountered. Tolerance for uniqueness, that which does not fit with our constructs, is essential in the early stages. Toward the midpoint of the information search process, some of the initial uniqueness takes on meaning as we build new constructs. At this point, thoughts become clearer and more focussed and selections of relevance become more pertinent and to the point. At the end of the process, the amount of redundancy in the information encountered and gathered can be expected to be much greater than the amount of uniqueness. Much of the initial uniqueness has been reconstructed into the familiar. The shift to encountering mostly redundant information lessens anxiety and raises confidence.

7.5 Mood corollary

Mood is a stance or attitude that the user assumes which opens or closes the range of possibilities in a search. An invitational mood leads to expansive actions. An indicative mood leads to conclusive actions. The user's mood may shift during the search process. An invitational mood may be more appropriate for the early stages of the search and an indicative mood more appropriate for the later stages.

A mood may be thought of as an attitude which determines one's approach to the task at hand. Kelly [18] describes two moods in any constructive process: one is invitational and the other indicative. Assuming a single mood, either invitational or indicative, throughout the entire information search process, may obstruct progress at certain points. The ability to alter mood as the search progresses allows for the accommodation of the different tasks in each of the various stages.

The bibliographic paradigm projects the notion that the singular task of information seeking is to gather and collect information rather than that of a series of different tasks within a constructive process. In this way, the traditional approach to information seeking fosters an indicative mood. For this reason, users may be expected to be impatient with the more invitational aspects of information seeking. It is not surprising that users have a tendency to move from selection to collection leaping over the critical invitational stages

of exploration and formulation. They can be expected to use indicative strategies such as copious notetaking when more invitational tactics such as listing interesting ideas would be more appropriate. An exclusively indicative approach to information seeking is in conflict with the actual experience of users in the information search process.

7.6 Prediction corollary

The search process may be thought of as a series of choices based on predictions of what will happen if a particular action is taken. Predictions are based on expectations derived from constructs built on past experience. Each of us constructs our own unique personal world. Therefore, the predictions and choices made in the search process may vary widely from user to user. Predictions may be expected to change during the search process as the user moves from uncertainty to understanding.

The concept of predicting outcome brings insight to the issue of relevance judgements. Relevance is not absolute and cannot be considered constant from person to person. Choices within the search process are unique to the individual and may be expected to vary considerably. For this reason, objective measurements of accuracy of information retrieval do not sufficiently determine effective performance.

The search process involves a series of choices of what users find relevant or irrelevant. Kelly [18, p. 64] states that a person chooses that which will extend and define his system of constructs. In the process of a search users seek information that will extend and define their understanding of the topic or problem. As constructs related to the topic are formed and clarified, choices of what information will extend and define are likely to change. What was relevant at the beginning of a search may not be relevant later and information not considered relevant early on may become pertinent in the later stages. For a better understanding of the predictions which drive choices, it may be necessary to elicit what was rejected as well as what was accepted and why the choice was made.

Users predict, from constructs formed through prior experience, what will be useful and expedient in information seeking. The predictions determine the sources that are used, the sequence in which they are used and the information that is selected as relevant from within the sources. Conversely, users' predictions determine sources, information and the ideas that remain unused or are discarded.

Predictions are also made about process. Expectations are formed through the holistic experience of information seeking. Therefore, personal constructs relate not only to the cognitive aspects of the process but also to the affective experience within the search process. Feelings of anxiety at the beginning of a search affect the choices one makes as do feelings of confidence in later stages. Predictions of outcome are likely to vary in accord with where the user is in the process.

7.7 Interest corollary

Interest increases as the exploratory inquiry leads to formulation in the information search process. Motivation and intellectual engagement intensify along with construction. Personal interest may be expected to increase as uncertainty decreases.

Interest, another element of the information seeking experience closely related to mood, was found to be an important factor throughout the search process in these studies. The user's interest was reported to increase after the formulation of a focus. When construction was well underway and the topic was personally understood, users responded that they had become more interested in the topic or problem. Motivation resulting from personal interest is more pronounced after the midpoint of the search than at the beginning. The information search process may be described as a gradual exploratory inquiry leading to discovery with interest increasing along with construction.

Under the direction of Marton, a group of researchers at the Institute of Education at the University of Gothenburg, Sweden, have made some important findings related to interest [34]. A number of researchers have studied motivation, investigating the explanations underlying the Yerkes-Dodson Law [35] which addresses the relationship between intensity of motivation and depth of learning. Fransson [36], in an extensive series of studies on intrinsic and extrinsic motivation, found that interest plays a significant part in determining whether a person adopts a surface or a deep approach in information processing related to learning. Limberg and Selden [37] have raised some important questions regarding the implications of this work to library and information science.

7.8 Summary

The uncertainty principle and the six corollaries propose a theoretical view of users in their search for information to gain deep understanding. Uncertainty at the initiation of the information search process is characterised by vague thoughts, anxious feelings and exploratory actions. Understanding, later in the process, is characterised by clear thoughts, confident feelings, and documentary actions.

Library and information systems and services based on the bibliographic paradigm ignore the holistic experience of information seeking. Attention is concentrated on the limited tasks of collecting and documenting. Systems and services incorporating a principle of uncertainty are challenged to consider the user's cognition, affect and action within the information search process. Interaction is directed to the constructive tasks of exploring and formulating. Until the triad of thinking, feeling and acting is incorporated into the theoretical framework of information seeking, interaction is likely to be fragmented and limited. The uncertainty principle proposes a basis for interaction into the process of learning from information enabling users to move from uncertainty to understanding.

8. AREAS FOR FURTHER RESEARCH

There are many promising directions for future research for developing the uncertainty principle as a conceptual perspective of information needs and use.

A particularly promising area for future research is evaluation of the use of information. Studies of evaluation have been limited primarily to assessment of system output. Relevance studies have centred on judgement of documents produced in response to a query. Little empirical study has been done on the actual use of information and how systems respond at the problem level [38]. Questions remain as to how information responds to the user's actual information need and what use is actually made of the information.

New perspectives on relevance are emerging which promote broader measures of information use [39–42]. Evaluation of the use of information in the different stages of information seeking needs to be studied. Assessment needs to be made of how information affects the constructive process of the user. A user-centred approach to evaluation of systems at the problem level represents information seeking over an extended period addressing questions of task complexity [43] and construction of meaning [44]. Broader criteria for evaluation beyond judgements of relevance need to be explored. More holistic criteria need to be identified which incorporate such factors as the underlying task promoting the information need, the user's personal perspective and interest, time allotted and availability of materials. Such evaluation may lead to the design of enabling information environments where people can find meaning as well as documents.

Accommodation of the user's perspective of information seeking presents library and information studies with a concern and a challenge. The concern is that in the present information environment rapid, unrelenting transmission of information has diminished the prospect of synthesis and the satisfying whole experience that comes from deep understanding. The challenge is that of designing information systems and services which enable people to move from uncertainty to understanding in an information world where one is threatened with the prospect of being in a perpetual state of uncertainty.

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REFERENCES

1. DERVIN, B. and NILAN, M. Information needs and uses. *Annual Review of Information Science and Technology*, 21, 1986, 3–33.
2. BUCKLAND, M. *Information and information systems*. New York: Praeger, 1991.
3. ELLIS, D. The physical and cognitive paradigms in information retrieval research. *Journal of Documentation*, 48, 1992, 45–64.

4. INGWERSEN, P. *Information retrieval interaction*. London: Taylor Graham, 1992.
5. WILSON, T. On user studies and information needs. *Journal of Documentation*, 37, 1981, 3–15.
6. TAYLOR, R. Question-negotiation and information seeking in libraries. *College and Research Libraries*, 29, 1968, 178–194.
7. BELKIN, N. Anomalous states of knowledge as the basis for information retrieval. *Canadian Journal of Information Science*, 5, 1980, 133–143.
8. BELKIN, N., ODDY, R. and BROOKS, H. ASK for information retrieval. *Journal of Documentation*, 38, 1982, 61–71 and 145–164.
9. DERVIN, B. *An overview of sensemaking research; concepts, methods, and results to date*. Seattle, WA: School of Communication, University of Washington, 1983.
10. SARACEVIC, T. Relevance: a review of a framework for thinking on the notion of information science. *Journal of the American Society for Information Science*, 26, 1975, 178–194.
11. BATES, M. Idea tactics. *Journal of the American Society for Information Science*, 30, 1979, 280–289.
12. BATES, M. The design of browsing and berrypicking techniques for the online search interface. *Online Review*, 13, 1989, 407–424.
13. ELLIS, D. A behavioural approach to information retrieval systems. *Journal of Documentation*, 45, 1989, 171–212.
14. INGWERSEN, P. Search procedures in the library analysed from the cognitive point of view. *Journal of Documentation*, 38, 1982, 165–191.
15. MARCHIONINI, G. *et al.* Information seeking in full text end-user-oriented search systems: the roles of domain and search expertise. *Library and Information Science Research*, 15, 1993, 35–69.
16. KUHLTHAU, C. *Seeking meaning: a process approach to library and information services*. Norwood, NJ: Ablex, 1993.
17. DEWEY, J. *How we think*. Lexington, MA: Heath, 1933.
18. KELLY, G. *A theory of personality: the psychology of personal constructs*. New York: Norton, 1963.
19. BRUNER, J. *Beyond the information given: studies in the psychology of knowing*. New York: Norton, 1973.
20. BRUNER, J. *Actual minds, possible worlds*. Cambridge, MA: Harvard University Press, 1986.
21. MAHER, B. *ed.* *Clinical psychology and personality: the selected papers of George Kelly*. New York: John Wiley, 1969.
22. KUHLTHAU, C. Developing a model of the library research process: investigations of cognitive and affective aspects. *Reference Quarterly*, 28, 1988, 232–242.
23. KUHLTHAU, C. Perceptions of the information search process in libraries: a study of changes from high school through college. *Information Processing and Management*, 24, 1988, 419–427.
24. KUHLTHAU, C. Longitudinal case studies of the information search process of users in libraries. *Library and Information Science Research*, 10, 1988, 251–304.
25. KUHLTHAU, C. The information search process of high-middle-low achieving high school seniors. *School Library Media Quarterly*, 17, 1989, 224–228.
26. KUHLTHAU, C., TUROCK, B., GEORGE, M. and BELVIN, R. Validating a model of the search process: a comparison of academic, public, and school library users. *Library and Information Science Research*, 12, 1990, 5–32.
27. KUHLTHAU, C. Inside the search process: information seeking from the user's perspective. *Journal of the American Society for Information Science*, 42, 1991, 361–371.
28. BATES, M. Subject access to online catalogs: a design model. *Journal of the American Society for Information Science*, 37, 1986, 357–376.

29. WHITTEMORE, B. and YOVITS, M. A generalized conceptual development for the analysis and flow of information. *Journal of the American Society for Information Science*, 24, 1973, 221–231.
30. SHANNON, C. and WEAVER, W. *The mathematical theory of communication*. Urbana, IL: University of Illinois Press, 1949.
31. YOVITS, M. and FOULK, C. Experiments and analysis of information use and value in a decision making context. *Journal of the American Society for Information Science*, 36, 1985, 63–81.
32. SPARCK JONES, K. *Retrieving information or answering questions?* London: British Library, 1990.
33. VAN RIJSBERGEN, K. A new theoretical framework for information retrieval. *ACM SIGIR Proceedings, Pisa, Italy*, 1986, 194–200.
34. MARTON, F., HOUNSELL, D. and ENTWISTLE, N. *The experience of learning*. Edinburgh: Scottish Academic Press, 1984.
35. YERKES R. and DODSON, J. The relation of strength of stimulus to rapidity of habit formation. *Journal of Comparative and Neurological Psychology*, 18, 1908, 459–482.
36. FRANSSON, A. Cramming or understanding? Effects of intrinsic and extrinsic motivation on approach to learning and test performance. In: ALDERSON, J. and URQUHART, A., eds. *Reading in a foreign language*. White Plains, NY: Longman, 1984.
37. LIMBERG, L. and SELDEN, L. Informationssökning och meningfullt lärande. *Svensk Biblioteks Forskning*, 1, 1993 (in press).
38. ROBERTSON, S. and HANCOCK-BEAULIEU, M. On the evaluation of IR systems. *Information Processing and Management*, 28, 1992, 457–466.
39. HARTER, S. Psychological relevance and information science. *Journal of the American Society for Information Science*, 43, 1992, 602–615.
40. SHAMBER, L., EISENBERG, M. and NILAN, M. A re-examination of relevance: toward a dynamic, situational definition. *Information Processing and Management*, 26, 1990, 755–776.
41. SU, L. The relevance of recall and precision in user evaluation. *Proceedings of the 55th annual meeting of the American Society for Information Science*, 29, 1992, 330.
42. TAYLOR, R. *Value added processes in information systems*. Norwood, NJ: Ablex, 1986.
43. MURTONEN, K. and JARVELIN, K. Task complexity affects information seeking and use. *Information Processing and Management* (in press).
44. SAVOLAINEN, R. The sense-making theory: reviewing the interests of a user-centered approach to information seeking and use. *Information Processing and Management*, 29, 1992, 13–28.

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