

Anomalous States of Knowledge as a Basis for Information Retrieval
Etats anomaux des connaissances comme base du repérage de l'information

by/par

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Most research and theory in information retrieval has been concerned with document representation and with the mechanisms of what is known as the "channel". This paper presents an alternative view of information retrieval, based on the problem of non-specifiability of information need and within a context known as the cognitive viewpoint. It is suggested that information retrieval ought to be considered from the point of view of the user's anomalous state of knowledge, a concept explained and discussed.

La majorité des recherches et des théories dans le domaine du repérage de l'information se sont attachées à la représentation des documents et aux mécanismes de ce que l'on connaît sous le nom de "canal". L'auteur propose une optique différente sur le repérage de l'information qui se rend compte du fait que le besoin d'information n'est pas spécifiable et qui opère dans un contexte connu sous le nom de point de vue cognitif. Il suggère de considérer le repérage de l'information en partant de l'état anormal des connaissances du client, concept qu'il explique et discute.

This paper will outline a framework or approach to information retrieval (IR), based on a cognitive point of view which considers the IR situation as a communication system in which the mediating role of the participants is primary (Belkin, 1977b; Hollnagel, 1979; De Mey, 1980). The traditional viewpoint in IR focuses on the general properties of IR systems, especially on the problem of document representation (e.g. Wellisch, 1980). Although my approach poses some conceptual and practical difficulties, I will argue that its initial focus on the states of knowledge and problems, goals and intentions of the participants in the IR situation offers solutions to some problems which have plagued IR system design. It may offer a way to integrate a number of apparently different phenomena and observations. The two points of view are, of course, not mutually exclusive; any sensible IR theory must take account of both.

Information Retrieval and Document Retrieval

Discussion in this paper will be limited to a rather particular view of IR. My basic premise is that information science, and hence IR, is a problem-oriented discipline, concerned with the problem of the effective and efficient transfer of desired information between human generator and human user (for background on this problem, see Wersig, Neveling, 1975; Belkin, 1977a). This premise limits concern specifically to human communication and means that this sort of IR will not be concerned, for instance, with the acquisition of knowledge by humans

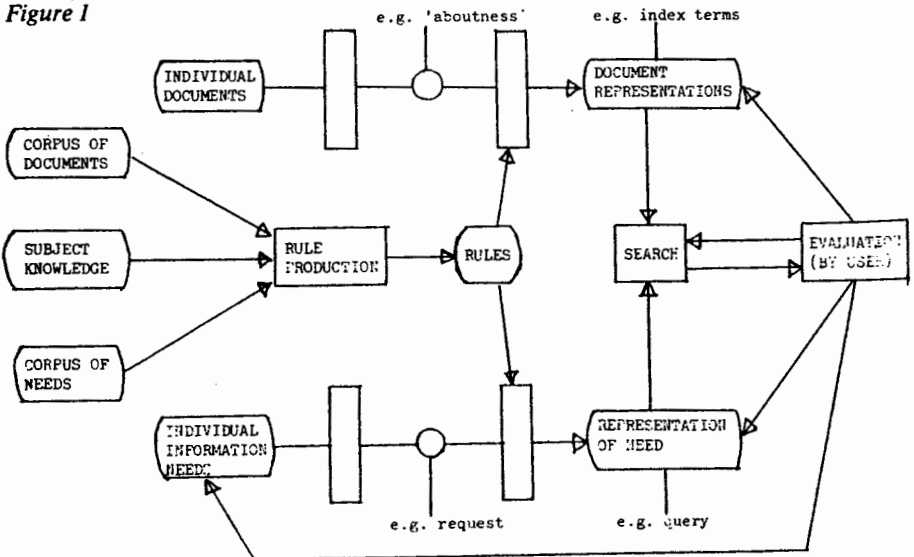
directly from the physical environment. By specifying desired information, the statement of the problem also limits concern to communication controlled or instigated by recipients (Paisley, Parker, 1965). Information in this context is interpreted as a particular structure associated with a text (Belkin, Robertson, 1976; Belkin, 1977a); this interpretation implies that IR systems are primarily concerned with whole texts or combinations of texts, rather than with elements or parts of texts. Text here means any semiotic structure and includes much more than documents, although documents tend to be the typical example. This focus on whole texts or combinations of texts also arises from my view of the function of IR systems: to help people solve problems, rather than directly to solve problems posed to them (as do, for instance, question-answering systems).

These factors together lead to the following description of the IR situation:

- a user, recognizing an information need, presents to the IR mechanism (a collection of texts and associated activities) a request, based on that need, hoping that the IR mechanism will be able to satisfy the need;
- the task of the IR mechanism is to present to the user the text(s) which it judges to be most likely to satisfy the user's information need, based upon the request put to the mechanism;
- the user examines the text(s) presented by the mechanism and the need is satisfied completely, partially, or not at all. The user's judgement as to the contribution of each text in satisfying the need establishes the usefulness or relevance of that text to the need (Robertson, Belkin, 1978, 93 modified).

Figure 1 is a schematic diagram of the sort of IR system that would operate within this situation. It is important to notice that this model of IR is actually a model of document retrieval — a debatable simplification — but it might easily be extended to the more general text retrieval. It seems unlikely, however, that further

Figure 1

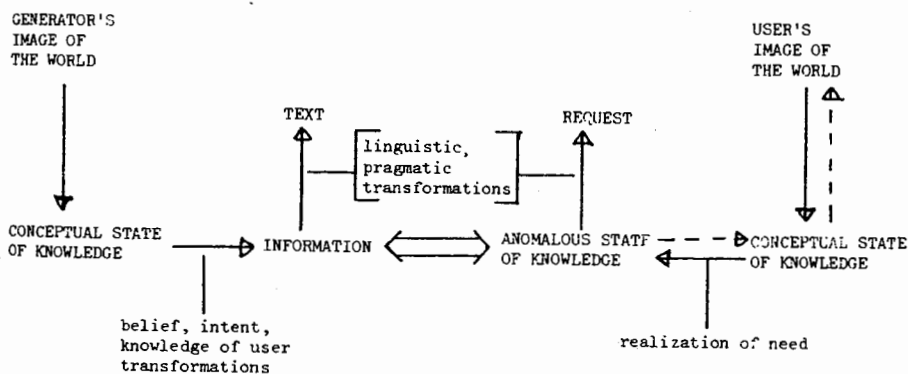


extension to question-answering or inference-making systems is possible within this framework — a serious limitation to the application of the cognitive viewpoint proposed here, although that viewpoint does not imply this limitation.

An IR Communication System

Within the context and presuppositions outlined, one can construct a communication system for IR (figure 2). In this system, a generator, such as an author, decides to communicate for some reason and to some audience some aspect of his or her state of knowledge or "image" of the world. What the generator knows about this topic is modified by beliefs, intentions, values, and so on, and especially by knowledge of the intended audience and context of communication. This modified state of knowledge, the information, is further amended by linguistic and pragmatic rules to become the text or that which is physically communicated. In the IR situation, this text is generally conceived of as some physical record which becomes a part of the IR system text store.

Figure 2



A Cognitive Communication System for Information Retrieval

From the other end of the system, a user decides to investigate or use some part of his or her state of knowledge or image, but on consideration, the user realizes that there is an anomaly in that state of knowledge with respect to the problem faced. This realization, in combination with intent and so on, leads to a recognized anomalous state of knowledge (ASK), which, further modified by linguistic and pragmatic considerations, becomes a request put to the IR system. This system is instigated by the recipient in the sense that the user, recognizing an ASK, goes to the IR system to resolve it. Furthermore, as indicated by broken arrows in figure 2, the user evaluates the information obtained from the system in terms of the ASK, the conceptual state of knowledge and of the problem leading to the ASK, and his or her entire image. The success of the communication is dependent upon the extent to which the anomaly can be appropriately resolved on the basis of the information provided. Thus, the system is also controlled by the recipient and is, in general, iterative.

The emphasis on the role of the user in the communication model and in IR compels one to recognize explicitly that representing users' needs is at least as important as representing texts. This means more than just user need surveys; it means that the corpus of needs is at least as important as the corpus of documents in producing rules for representation, and perhaps more so (figure 1). That appropriate rules for need representation are more important than appropriate rules for text representation could be justified by noting that evaluation of system performance is in terms of the user's state of knowledge, desires, and so on, rather than in terms of the author's. One cannot, of course, carry this argument too far, for text representation is obviously important to the success of an IR system. Nevertheless, the argument does suggest that one ought first to consider needs, and methods appropriate for their representation, and then within that framework to develop appropriate text representations and retrieval strategies. I suggest that considering information needs from the point of view of ASKs provides a framework suitable for accomplishing this task.

Anomalous States of Knowledge

What is an ASK? This concept is not wholly original but rather a synthesis of a number of previous suggestions. It is an attempt to take serious and explicit account of facts of the IR situation which are well documented but largely ignored in the theory and design of IR systems.

The basis of the ASK idea can be seen in Taylor's schema of levels of question, in which he suggests that questions put to IR systems go through four stages, the first two being the *visceral* need or the internal, actual but unexpressed, and perhaps inexpressible need for information, and the *conscious* need or the realized, within-brain, ambiguous and ill-defined description of the need (Taylor, 1968). Kochen (1975) has described the relationships between problems, needs, and requests in similar terms, the *problem* being roughly equivalent to Taylor's first stage, the *need* to his second stage. Wersig (1971) suggested that what underlies the concept of information need is the individual's recognition of a problematic situation. This recognition can be interpreted as the individual's model of some aspect of the external world and of his or her position in it with respect to some particular situation. The problematic aspect is that the individual recognizes that the model is insufficient, usually in terms of some desired goals, and knows that information is needed in order to reduce uncertainty, for instance.

The user's initial difficulty in specifying or even explicitly recognizing what is wrong, and especially in recognizing and specifying what is necessary to make things better is a common idea in these models of the need situation. By considering the situation in terms of the communication system suggested in this paper (figure 2), one can perhaps relate this difficulty to the concept of an ASK. In this context, the user first decides to consider some particular aspect of his or her state of knowledge (for example, definition of a particular problem or statement of a general goal to be achieved) but realizes that this state of knowledge is inadequate in terms of the initial decision. In our communication model, the perceived inadequacy is interpreted as an aspect of the user's anomalous state of knowledge. Anomalous is used as the descriptive term not only because it leads to

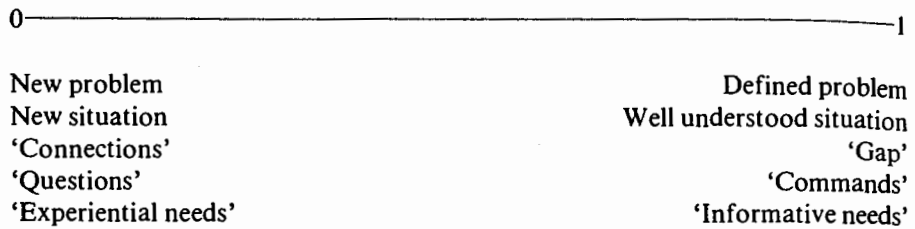
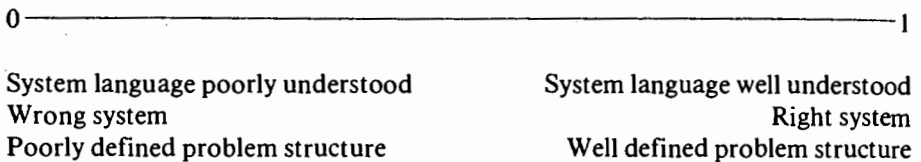
a good acronym, but also because inadequacies in a state of knowledge can be of many sorts, such as gaps or lacks, uncertainty, or incoherence, whose only common trait is a perceived "wrongness". An ASK shares characteristics of Taylor's levels one and two and is roughly equivalent to Kochen's need. However, by considering the situation in terms of knowledge and especially in terms of anomalies, one gains the advantage of having a specific target for efforts at representation and analysis: the anomaly.

The ASK idea also allows one to explain the problem of non-specifiability of information need. The idea of non-specifiability of need is implicit in the concept of relevance as applied to IR system evaluation; system performance is almost invariably evaluated according to judgements of the relevance of the system's output assigned by humans, either the users who posed the questions or external experts. In these judgements, there is always some difference between relevance as predicted by the system and relevance as assigned by the human. Systems designers and evaluators now assume that this situation will hold, and probabilistic IR (Maron, Kuhns, 1960) is an explicit recognition of this situation. Although some of this mismatch may be attributed to inappropriate representation of text, it is usually attributed in its largest part to an incongruity between the request as stated and the need underlying the request.

Some reasons for non-specifiability of information need have been suggested by various researchers: Taylor (1968) distinguished between *questions* and *commands*, and McFadyen (1975) between *informative* and *experiential* inquiries. Although these classifications and others like them are dichotomous, it may perhaps be more useful to view the categories as approximating two ends of a scale or continuum of specifiability of information need (figure 3). At one end of the scale in figure 3a are needs which are precisely specifiable or nearly so; that is, the user knows exactly what is necessary to satisfy the need. An example of this type of need or problem is a person writing a review article who needs a complete bibliography on the topic. Another might be some of the needs associated with management information systems. At the other end of the scale are needs which cannot be specified or can be specified only very vaguely; that is, the person is conscious of a need but does not know what information would be appropriate to satisfy it. An example of this type of need is a researcher entering a new field or problem area who needs to know how his or her knowledge relates to the new problem. Another example is a person entering a new social structure, such as a new city, country, or job, who needs to know how to get on in the new situation. In both cases, a problem is recognized, and it is recognized that information might be necessary to resolve the problem, but precisely because of the inquirer's lack of knowledge about the problem area, it is impossible to specify what would resolve it.

Another type of non-specifiability of need has to do with expression of the need as a request (figure 3b). From this point of view, the major difficulty lies in characteristics of the specific system which the user has approached. One should notice, however, that no need which is at the lower end of the cognitive spectrum will ever be at the upper end of the linguistic spectrum, for the problem structure at least must be well defined in order to formulate a precise request. Even if the need lies at the upper end of the cognitive scale, for various reasons it may not be

Figure 3

*3a. Specificifiability at the cognitive level**3b. Specificifiability at the linguistic level**Scales and Levels of Specificifiability of Information Need*

very precisely specificifiable at the linguistic level. The system language may be inappropriate, for instance a broad classification scheme when high precision is desired, or the language may be poorly understood. It may be that some situations, even if well understood at the cognitive level, defy description at the linguistic level; many have experienced difficulty in communicating to others, for example in a written paper, that which they feel they know perfectly well.

Thus, there appear to be at least three separate factors which could account for mismatch between request and need: the texts have been inappropriately represented (wrong system or poorly understood language); the need cannot be expressed appropriately in the system's terms; or need itself is unspecificifiable at the cognitive level. The first two factors lie on the linguistic scale of specificifiability, but since linguistic specificifiability is dependent upon cognitive specificifiability, if the third factor pertains, then linguistic specificifiability is only secondary to it. It seems to me that the typical case in IR is that needs are non-specificifiable at least to some extent, and therefore that the general problem resides initially at the cognitive level. If this is indeed the case, then a number of phenomena can be explained, or at least examined, within one framework. For instance, we can understand why there is almost always a distinction between user and system relevance and why the reference interview is such a difficult task. We can also see why, even given complete freedom of language, the question presented to an IR system is usually only an approximation to what might be necessary to resolve the need which gave rise to the question.

The cognitive scale of specificifiability of need can be interpreted as representing degree to which the state of knowledge giving rise to the need is well formed. At the upper end of the scale, the individual's knowledge of the topic is perhaps well enough formed to be able to identify a particular fact or method whose

acquisition will make the knowledge adequate for the purpose; that is, the anomaly can be specified. At the lower end of the scale, the individual's state of knowledge of the topic is ill formed in terms of the problem or situation; the individual does not know what aspects of knowledge will be useful and especially does not know precisely in what way his or her knowledge ought to be modified in order to achieve the eventual goal. Considering this spectrum from the point of view of states of knowledge in effect describes the situation as one in which there are various kinds of ASKs, ordered upon the scale according to the degree of coherence of the state of knowledge.

Thus, considering the problem of non-specifiability of need from the cognitive point of view explains a major characteristic of ASKs, and looking at the problem from the point of view of ASKs provides a single schema for considering and identifying the problem of non-specifiability of need. Furthermore, the ASK idea provides some suggestions as to what one might look for in determining need, and as to how to incorporate the problem of non-specifiability of need explicitly into IR theory and systems design.

Implications of ASKs for IR

The ASK idea implies that the sorts of IR systems now in use, based on the principle of "best match" are inappropriate to the IR situation (Belkin, 1980). Such systems depend crucially upon exact specification of what is needed to resolve the user's information problem, and yet, given the hypothesis that information need is non-specifiable, such a system cannot work at theoretically optimal limits.

The ASK idea also implies that one should begin IR system design by developing representational schemes appropriate for ASKs, rather than for documents. A third, very important implication is that different retrieval strategies may be necessary for different kinds of ASKs. We may at least speculate that ASKs will fall into classes which require different sorts of answers and therefore different retrieval strategies, each designed to retrieve texts appropriate to the class of anomaly. These implications of the ASK idea indicate how it might be used to incorporate non-specifiability into IR theory and IR systems design. A specific system designed on the ASK hypothesis has been discussed in Belkin, Oddy (1979) and Belkin, Brooks, Oddy (1979).

For IR in general, the ASK idea suggests that the user's knowledge is the central issue in the IR system. Thus, an IR system ought to be based on means for discovering and representing the user's knowledge of the problem under consideration, with special attention paid to the anomalies which prevent specification of need. This approach in turn means *not* asking users to specify questions to put to the IR mechanisms, but rather trying to obtain data from them which take account of the fact of non-specifiability and then generating representations which specifically seek to identify anomalies. It seems likely that a good rule for obtaining such data is to avoid placing mechanism-related constraints upon the user, while emphasizing the significance of the ASK or problem constructs. Oddy's (1977) suggestion that needs may be discovered through dialogue rather than through specification is a significant example of this general approach.

Furthermore, the ASK idea suggests that IR systems ought to be designed to take account of different classes of ASKs, and that different retrieval strategies may be needed to do this. Classifications of questions and problems are steps in this direction (e.g. Saracevic, 1978). Research and theory ought to be directed toward trying first to develop classifications of the anomalous characteristics of states of knowledge and secondly toward identifying strategies appropriate for resolving those classes of anomalies. Best match strategies are one obvious candidate, at least for well specified anomalies, but there are certainly classes of ASKs for which this type of strategy is inappropriate.

The ASK hypothesis also suggests that iterative interaction is the most appropriate mode for IR systems (figure 2). This certainly is not an innovative suggestion, yet some specific consequences of considering the situation from the ASK point of view are significantly different from current practice. For example, evaluation probably ought not be in terms of relevance, at least not in the first instance, but rather in terms of how well the mechanism has interpreted and represented the user's ASK, and whether an appropriate retrieval strategy was chosen. It ought also to be assumed that the initial system response to the user will probably serve to specify the ASK more precisely, rather than to resolve it. Finally, it is assumed that the user's knowledge outside that represented in the ASK will be significant in the evaluation of system response; therefore, affective as well as cognitive issues must be considered.

Finally, the ASK idea seems to imply that user warrant ought to play a much stronger role in rule production for representation within the system than literary warrant. This implication means that the corpus of needs provides the primary data, and that the evidence of the corpus of documents ought to be interpreted in terms of the needs or ASKs. This is certainly a different approach than that taken in most operational IR systems, although there is a noticeable trend in IR research in this direction (Mark Pejtersen, 1980).

Problems and Prospects

The ASK framework seems to me to offer the possibility for substantial improvement in IR system performance, or at least the possibility of investigating explicitly the effect of recognition of non-specifiability of need. It certainly provides an alternative research program in IR to that derived from the more traditional document-based theory. It implies that the first order of business is to investigate the nature of needs and the structure of the states of knowledge which underlie needs, and that research should be directed toward representation of ASKs before or in conjunction with research on representation of texts. In this sense, although the ASK idea does not provide a framework from which falsifiable consequences can be easily generated, it does provide a program for research which can be tested in terms of system results. Unfortunately, although it is perhaps useful in an integrative sense, it does raise a number of problems which more traditional IR theory has avoided or never had to face, at least to the same extent.

Among the problems raised by the ASK framework are the representation of knowledge and especially of that which is not known, determining the effect of a given text on a given state of knowledge, discovering retrieval strategies other

than best match, and predicting the effect of order of texts on their effectiveness in resolving anomalies. This last point has been mentioned in the IR literature only rarely, and usually with some trepidation (e.g. Goffman, 1969; Robertson, Belkin, 1978). It arises in this context because the ASK framework assumes that the user's ASK will be changing on receipt of information, leading to a different ASK, and that therefore there is probably some optimum order of presentation of potentially useful texts. This point of view also assumes that it is unlikely that any one text will ever satisfactorily resolve any ASK; rather the usual solution will be some set of texts, in an appropriate order. This assumption raises formidable problems indeed, problems which are probably the reason that this issue has not been widely discussed in IR but which must eventually be faced if the ASK framework is to be applied. One of the strengths of the ASK framework may just be its ability to generate interesting research topics.

I believe that I have shown that the ASK framework is both appropriate to the IR situation and is a potentially useful approach for theory building and system design within that situation. Although it does not immediately imply any specific theory or system, it does offer guidelines which can be used for such activities. The ASK framework certainly raises more problems than it answers, but this is not an unhealthy sign. At the very least, it explicitly takes into account that which has implicitly been at the core of IR: non-specifiability of need. In this respect, it seems to me to offer a better way to look at IR.

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