Information and Information Science in Context

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The article (*) demonstrates the development of information science through three stages: its emergence prior to the second World War, its search for identity and alliances during the sixties and seventies, and its establishment as a discipline during the period 1977–80. The scope and present state of the discipline is discussed, pointing to five major areas of concern for information science as well as a number of core sub-disciplines. Current and future trends are emphasized.

Based on the cognitive view, as defined in 1977 by M. De Mey, the author discusses the understanding of the concept of "information" in relation to the discipline and proposes a consolidated concept which has to satisfy dual requirements in relation to both sender and recipient of conveyed messages, in order to be operational from a current perspective of information science. The proposal relies primarily on arguments and suggestions previously put forward by G. Wersig, A. Debons, and F. Machlup, and extends the information concept proposed by N. Belkin in 1978. The author draws special attention to the views expressed by the late B. C. Brookes by reviewing and re-considering the arguments associated with his "fundamental equation" for information science. The implications of the consolidated concept are briefly discussed.

1. Introduction

The aims of this article are to outline the scientific landscape in which information science operates and to propose and discuss an operational concept of information in the light of a cognitive view. The emergence and scope of information science and its relationship to other scientific disciplines

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are briefly analysed. The major areas of interest to researchers and professionals in the field are defined.

The reasons for a renewed discussion of information science domains and borderlines to other disciplines are two-fold: 1. Since the seventies, a new generation of information professionals and scientists has emerged showing a keen interest in the foundation and developments of the field. In this respect, an important congregation of highly interested colleagues is made up of members of the profession in the East European countries, Balticum and Russia; 2. During the eighties, R & D work in the field seems to indicate a profound shift from focussing on the technological aspects only to viewing the human cognitive and behavioural sphere in *interaction* with information technology as the main focus in information transfer.

This has implications for the interpretation of the historical dimensions leading to the present state of art in information science as well as our understanding of the function of information in society.

The understanding of the concept of information for information science presented by the author is a further development of N. Belkin's concept from 1977/78[1,2] as well as G. Wersig's earlier work on the issue[3,4]. It incorporates cognitive analyses of B. C. Brookes' Fundamental Equation for information science[5], orginally initiated by Ingwersen in 1984[6]. The innovation of the consolidated concept lies in its explicit emphasis of conditions for both the sender *and* the recipient as to when we may talk of information associated with conveyed messages.

The article starts with an outline of the emergence of information science, viewing the field in a framework of related sciences of information categorised according to interdisciplinary, disciplinary, and applied levels.

This is followed by a discussion of the various attempts for information science to merge with other disciplines – or to be merged – in order to manifest a stronger scientific position. Two major trends are considered: a move towards communication and a merger with computer science into informatics. The struggle for survival and the striving for consensus are analysed.

In the author's opinion the turning-point seems to emerge between 1977 and 1980. The reasons for this view are argued, leading to the formulation of the scope of the field as it stands today. The basic phenomena, problems and areas of concern for information science are demonstrated and discussed.

This leads to a critical analysis of major attempts to define or understand the concept of information for information science, followed up by the proposal for a consolidated concept by the author which includes conditions as to both generator and recipient. Finally, selected implications of the proposal are outlined, in particular those associated with measurement of information in information science and its utility in related fields.

2. *The emergence of information science*

Information science is a young discipline. The earliest formal use of the term information science dates back to 1958 when the Institute of Information Scientists (IIS) was formed in the UK. According to Farradane, the use of the term information scientist may have been intended to differentiate *information* scientists from *laboratory* scientists, since the main concern of the members was with management of scientific and technological information[7]. The members were scientists from various disciplines, often highly distinguished, who devoted themselves to organizing and providing scientific information to their fellow researchers in R & D institutes and industry. This fact provides us with important clues as to the understanding of the emergence and development of the discipline.

By naming themselves information scientists the members of IIS obviously wanted to stress the importance of the study of (scientific) information and the *processes involved* in scientific communication. Hereby their work was a continuation of previous scientific attempts to deal with problems of organisation, growth and dissemination of *recorded* knowledge, carried out before the Second World War. First H. E. Bliss[8] published his studies in the organization of knowledge, preparatory to developing his bibliographic classification, carrying an introduction by the philosopher John Dewey. A second area of intellectual investigation in documentation was opened up with the quantitative study of bibliographic production. S. C. Bradford first drew attention to a *bibliometric* distribution that has since been widely studied[9]. Slightly earlier, other statistical means were applied to measure productivity in the form of publication ratios among scientists by A. J. Lotka[10] as well as to word frequencies in texts by G. K. Zipf[11]. Third, during the thirties, *social survey methods* were first applied by D. Wapples in 1932 to studying the use of books and libraries[12]. The Indian mathematician S. R. Ranganathan initiated the formulation of his "five laws of library science" at the same time. He himself stressed that the laws were not scientific generalizations but norms, principles, guides to good *practice*: "every reader his book"; "books are for use"; "every book its reader"; "save the time of the reader, and of the staff"; "a library is a growing organism"[13]. The latter principles predict information management as an important aspect of information science.

However, the notions "book" and "practice" demonstrate the influence of the *current information technology* on the actual handling and accessing processes of recorded knowledge; the fact that all methods and theories applied to these processes, during approx. five millenia of clay-tablets and paper techniques, encouraged the development of principles and skills of a practical nature. Traditionally, the agents of these processes are librarians and documentalists. Their trade is librarianship (library science) and documentation. Exactly at a point where information technology went through a fundamental change with the application of the computer technology, information science was born. Librarians typically organize, analyse and provide access for all kinds of users to contents of documents. Documentalists do the same thing, but tend to exploit a wider variety of media and formats and traditionally limit their work to scientific-technical documents and users.

Information scientists emerge mainly from the ranks of documentalists, being aware of the wider aspects of scientific investigations of the processes of generation, representation, management, retrieval and use of information.

It is the increasing problems of both physical and intellectual access to a very fast growing body of (scientific) knowledge in the form of the "document explosion" since 1945, coupled with the increase in the complexity of problem-solving at all levels throughout the world and the opportunities offered by the new information technology, that gave birth to the discipline. Ranganathan's principle "every reader his book" is forced to change, carrying more qualitative and specific dimensions to it: "the most *relevant* piece of text to each reader". The problem of relevance will always be under investigation.

During two decades, 1958–1977, information scientists as well as researchers from other fields attempted to establish the core areas of research in information science and to define its boundaries to other disciplines. They were helped by the fact that other related fields, such as information theory, the systems sciences and computer science, emerged a short while before or at the same time. This may seem a paradox since these post-war disciplines all have in common the handling of data in various ways by the same new technologies. Do they leave space for information science? At a first glance independence seems difficult. By evolving from something apparently so trivial and hence not a science, i.e. the practice of documents and the skills involved, information science gives cause for discussion. In contrast to the other new fields, information science does not emerge from a well-established major scientific domain, such as electrical engineering, mathematics or physics. This lack of an independent theoretical foundation was outlined in 1980 by B. C. Brookes in his introduction to the Popperian ontology and its relevance to information science. He states[14]:

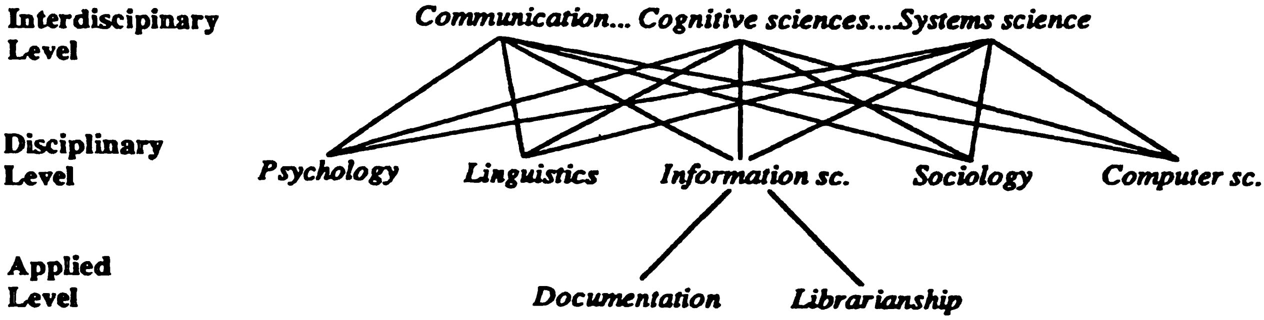

Fig. 1. Information science viewed as one of several sciences on information.

> Theoretical information science hardly yet exists. I discern scattered bits of theory, some neat in themselves but which resist integration into coherence. So there are no common assumptions, implicit or explicit, which can be regarded as its theoretical foundations. Information science operates busily on an ocean of commonsense practical applications, which increasingly involve the computer ... and on commonsense views of language, of communication, of knowledge and information. Computer science is in little better state. (p. 125).

On the other hand, in most of the new computer dependent fields debates concerning the nature of "information", "knowledge" and epistemological issues, as well as intermingling of theories and between fields took place during the same period[15]. These discussions support an *interdisciplinary approach* to all the fields, which again provide a framework for an understanding of the theoretical and applied objectives and limits. The situation from 1958 and onwards can be illustrated by Figure 1.

The problems for information science with respect to its borderlines to other disciplines are mainly found on interdisciplinary level, less often on disciplinary level. A core dimension, noticed by other fields, is that information science actually is the one which studies large *text* entities containing preserved knowledge – with more interest in solving theoretical and practical problems of its organisation and representation in systems for later retrieval and use on demand, than in the technology itself. The latter being the means to the former. Consequently, important areas of common interest between information science and other disciplines may develop. One may state that its *applied level* contributes to its recognition.

More important, during this period information science starts producing research results and theories of its own. These are often highly relevant to other disciplines, for example to computer technology applications in medicine, engineering and chemistry, in relation to text indexing, retrieval and transfer. The research efforts are carried out by applying, some may argue by leaning heavily on, a number of established theories from various fields.

For instance, the behavioural science contribute on the methodological side, and provide a framework for understanding the use of information in the context of society[16]. Slightly earlier, G. Wersig applies communication theory to model knowledge transfer[3]. Partly based on communication, partly on statistics, E. Garfield explores and develops his unique theories and techniques on citation analysis in science, published in 1979[17]. Linguistic theories concerning syntactics and semantics provides the bases for theories and developments of text representation and retrieval[18]. C. E. Shannon and W. Weaver's quantitative formulation for the coding and transmission of signals in a message, issued in 1949, have a recognized influence on theory construction[19]. R. Fairthorne applies it, as well as communication theory, to producing his classical Notification hexagon consisting of the interacting elements in an information system[20], later further developed by C. N. Mooers[21]. Its mathematical possibilities and relevance to information transfer are analysed by M. F. Lynch[22] and reviewed by P. Zunde and J. Gehl who concentrate on problems of aggregation of information, information decay, information measures and performance criteria, and extension of information theory[23].

These approaches to theory generation, although rather scattered and not providing one coherent foundation, support the recognition on a disciplinary level of the nature of information science and its relationship to the interdisciplinary fields mentioned.

This analysis leads to the observation that *library science* is a special R & D activity within information science. Library science, in the author's opinion, is concerned with the information processes that take place *in libraries*. As such, library science becomes a special case where, for instance, information retrieval is called reference work and information management is named library management. A similar special case is "documentation theory", which is mainly concerned with generation, transfer and use of scientific information.

3. *Alliances, identity or exaggeration?*

As can be expected, the flow of theories and viewpoints between the disciplines, horizontally on disciplinary level and vertically from interdisciplinary level downwards (see Figure 1), creates various attempts during the period for information science to merge with other fields – or to be merged – in order to manifest a stronger scientific position.

Two major trends are visible: a vertical move towards *communication*, and an attempt horizontally to merge with *computer science* into *informatics*.

Communication theory, which concerns itself with the rôle of language, the nature of movement and other methods for conveying meaning, is perceived by some scientists not only to contribute to, but to be the meta theory for information science. This has been suggested and discussed by T. Saracevic[24] and W. Goffman[25].

This trend does seem logical in the sense that transfer of recorded knowledge involves transactions and communication of meaning between humans, and between humans and systems containing conceptual structures. Fairthorne's notation scheme, Wersig's sociocommunicative views, research on scientific communication and several approaches to information retrieval and indexing demonstrate this allegiance to communication. The relationship seems reinforced during the eighties under the influences of a more user-oriented research view and the cognitive sciences. As a consequence, some US faculties of communication and library and information science did merge from the mid-eighties. Basically, the allegiance mainly suits the researchers studying the behaviour and interaction of the human elements of transfer of recorded knowledge.

In contrast, some information scientists, focussing mainly on systems and information technology applications in relation to knowledge organisation and transfer, demonstrate a drive towards *computer science*. H. Wellish analyses this possibility[26] and S. Gorn actually advocates a merger between the two fields into *informatics*[27]. This notion is close but not identical to the French "informatique" which, in general, designates a wider range of information technology applications, with emphasis on their technological aspects. Very recently, Zhang Yuexiau discusses the definitions of information sciences[28]. In his analysis he states that there is "not any real justification to replace computer science by information science or informatics", although he allows for a renaming into "computer and information science" (p. 483–485). In fact, it might have been logical to join the information retrieval, representation and management elements from information science with the software and AI sides of computer science – from a computer science point of view. Certain computer departments in university in the UK and USA do incorporate the information retrieval elements in their curriculum and R & D activities, e.g. Amherst, Mass. or Glasgow. The problems for information science would, in such a case, consist of maintaining its behavioural aspects and links to practice in librarianship and documentation. However, the subfields mentioned from the two disciplines increasingly cross and cooperate, e.g. as shown by Wormell[29] and in several ESPRIT projects. For example, the KIRA (Esprit 1117) and the SIMPR projects (Esprit 2083), involving

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AI theories for knowledge base design. The KIRA project (Knowledge-based Information Retrieval Assistant) builds on theories for intermediary performance as well as thesaurus theory; SIMPR (Structured Information Management: Processing and Retrieval) takes advantage of classification and indexing theories originating from information retrieval. The close ties between computer science and information science are mainly demonstrated by the Informatics conferences starting in 1973 and the initiation, in 1978, of the yearly ACM-SIGIR conferences.

"Informatics" unfortunately also carries another meaning to it. Since 1968 the Russian keyfigure in documentation, A. I. Mikhailov, designates "informatics" to the study of scientific communication and knowledge transfer, i.e. to contain the theoretical level of documentation alone[30]. The effect on East European information science research is notorious.

The most coherent proposal for a merger with computer science, as well as other interdisciplinary fields, originates from the Swedish systems scientist K. Samuelson, who created a department based on these principles. Cybernetics including communication and control and the systems sciences are seen as closely related metadisciplines to informatics, which incorporates the information and computer sciences as well as information technology. The well argued suggestion is called SCI, Systems, Cybernetics, Informatics[31].

In parallel to the described trends to relate closer to various fields or theories, the major part of the information science community attempts to solve the identity problem on its own. Several research conference proceedings, as well as individually published studies, contain titles that mirror the striving for consensus in information science, for instance: *Information science: discipline or disappearance?*[67]; *Information Science: Search for Identity*[32]; *Perspectives of Information Science*[33]; *The fundamental problem of information science*[34]; *Information: one label, several bottles*[35]; *Towards a true information science*[36].

Aside from demonstrating a struggle and a wish for coherence the cited titles cover a great number of valuable research works and contributions to the understanding of specific elements of generation, organisation, retrieval, transfer and use of information.

In retrospective, however, this fragmentation and specificity of research interests and scientific background knowledge among scientists in reality produced effective obstacles for the achievement of an independent consensus on disciplinary level. A. Debons, a leading US information scientist during the entire period, may have sensed this problem very accurately when he, in 1977, at the 2nd IRFIS Conference in Copenhagen, analysed the situation. In a critical essay he proposes *informatology* as a meta-science[37], based on suggestions put forward already[38].

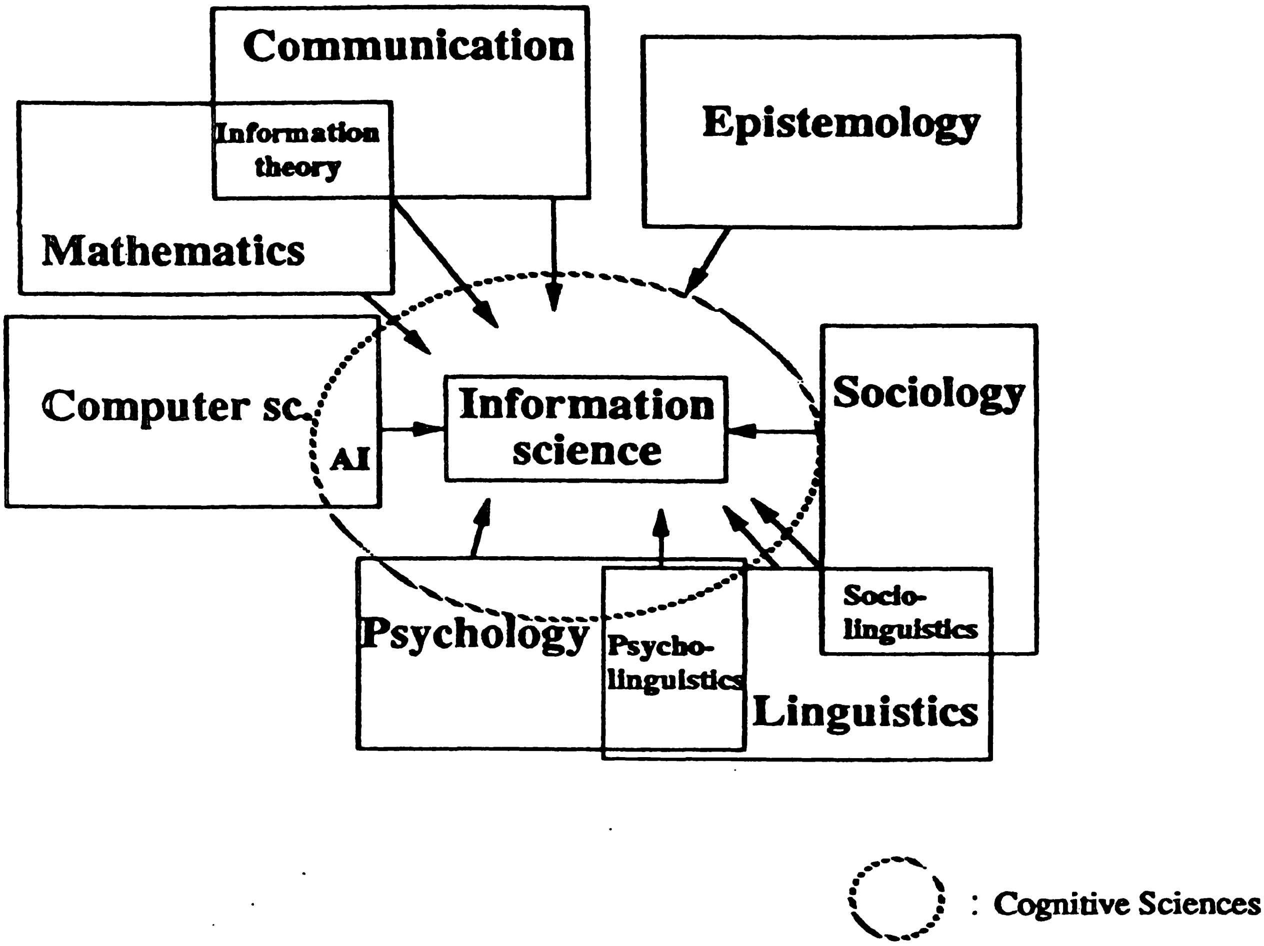

Fig. 2. Scientific disciplines influencing (—>) information science.

He operates within two frames of reference concerned with the issues of foundation for information science. The first frame regards information science as the body of understanding which concerns, for instance, scientific flow of knowledge or the organisation of information for better retrieval. To Debons this formulation looks for practical (applied) solutions, mostly through the establishment of new procedures and technologies.

The second frame of reference regards information science as directed towards an understanding of the "phenomenon of information" – discovering fundamental laws governing the experience. He calls this the "science of information" – *informatology*. He defines it "as a process leading to a 'state of the information system'". In practice, these two frames are intermingled although their respective foundations may not be the same. Debons continues to propose a step forward resolving the confusion, also stated by Brookes previously, by viewing information science as based on three primary factors concerned with the functioning of organisms: "the creation or generation of states *(generation);* the ability to use states in the accomplishment of tasks *(utilization);* the capacity to convey to other organisms indications of our states (transfer or *communication*)".

To Debons the human organism is a model information system, and he strongly advocates that it is the *interrelationship and interaction* of the three functional factors that constitutes the system, not the three separately conceived.

The reason for analysing Debons' view rather carefully is that, with a minor modification or reinterpretation, it does point towards a common understanding and provides an identity for the field as well as it justifies the contributions from other scientific disciplines dealing *separately* with generation, transfer and use of information: psychology, linguistics, communication, computer science, etc.

In the author's opinion, he *exaggerates* the goals and value of information science. When he attempts to lift it up above the disciplinary level (see Figure 1), he encompasses other established disciplines. Debons' first frame of reference refers clearly to the applied level. His second reference frame, however, places the "phenomenon of information", i.e. the object of information science, on a level already occupied by other disciplines and theories that are concerned with "information as a process leading to a state of the information system". For example, the cognitive sciences, the systems sciences, and epistemology. There does not seem to be any space nor any justification for "informatology" (or science of information) on this level. The author finds it more fruitful to apply Debons' proposal to information science on a *disciplinary level.* The condition for a disciplinary level is to accept an understanding of the phenomenon of information in the context of *recorded and demanded knowledge.* The same condition applies to the interaction of the three functional factors constituting the system. Hence, by modifying Debons' proposal, it may become more visible what information science ought to study, and from which other disciplines it may receive or provide valuable contributions (see Figure 2).

This tendency to *exaggeration* has made information science more vulnerable than the fragmented and incoherent theory developments mentioned earlier – and it still is. For example, it makes little sense when B. C. and A. Vickery very recently widen the scope of information science to be "the scientific study of the communication of information in society"[39] (p. 11), hereby postulating an umbrella-rôle, covering e.g. mass-communication and communication proper, which it cannot fill.

Figure 2 outlines the most important disciplines influencing information science.

Previously, figure 2 has been published in slightly different versions by Ingwersen ([42], p. 84) ([51], p. 208). The arrows designate from where information science mainly obtains inspirations and theoretical input as discussed above. Disciplines like AI, becoming influential in the eighties, are included. The reason for exhibiting the cognitive sciences, understood as the intersection of linguistics, artificial intelligence (AI) and psychology as stated by Shank and Abelson[40], is to stress a direct influence of these fields mainly in relation to information retrieval (IR). In this respect information science can be seen basically as a cognitive science.

4. The turning-point 1977–1980

What seems to emerge between 1977 and 1980 is an identity and the scope searched for during previous decades. Several significant publications on the matter provide profound analyses that indicate the turning-point for information science as a discipline. It becomes more mature and well-defined.

The first to appear was an analysis of the understanding and use of the concept of information as seen from an information science point of view by Belkin[2]. As can be expected the interpretations and different uses of the concept are rather scattered, depending on the scientific viewpoint and the research area in which the concept is applied. The paper suggests a scheme for requirements of an information concept for information science. In addition, it outlines a framework for information science which is discussed and elaborated on in grater detail in section 5.

A second publication is the introduction of Karl Popper's ontology as well as the cognitive view by B. C. Brookes[5,14]. Brookes argues that Popper's "Three-world model" provides a framework for understanding the nature of information science. In the Three-world model World 1 consists of nature and human, physical artefacts, such as buildings, books or computers. World 2 is "subjective knowledge" within the mind of individuals, and World 3 consists of "objective knowledge", i.e. recorded knowledge, mainly generated by humans[41]. The difference between World 1 and World 3 can be illustrated by the sentence "this was really a heavy book". Brookes claims that especially the world of "Objective knowledge", World 3, consists of characteristics of major interest to information science. He relates the cognitive view to the Popperian model in order to admit the concept of information and its relation to subjective and objective knowledge. Brookes' contribution – his Fundamental Equation – is discussed in section 6.

In Brookes' view the study of the interactions taking place between World 2, "Subjective knowledge", and World 3 forms "the theoretical tasks for information science, so to help organizing knowledge rather than documents for more effective use"[14] (p. 128). This observation is obviously correct and useful in the sense that it may explain what information science and librarianship *should do*, but have not yet achieved. It is with respect to knowledge acquisition and representation that Popper's ideas seem most relevant. Concerning these aspects Ingwersen points out[42] (p. 89–90):

> ... that hitherto we have seldom succeeded in allowing for *direct intellectual access* to the potential information or objective knowledge. Most information retrieval systems point to documents or parts of documents, giving *physical access,* or at maximum *bibliographic access* via representations, to World 1 objects, i.e. to artefacts like articles, books, reports, etc. placed in remote archives.

This so-called "tripartite conception of accessibility" and the serious problems involved are further discussed by Wormell[43].

Brookes goes further in using the Popperian ontology and rather exaggerates the potentiality of information science, by claiming World 3 to form "a territory which no other discipline has already claimed"[14] (p. 128). For many decades, however, in psychology, history, history of science and literature, researchers have analysed World 3 and the specific phenomena of interaction with World 2. Its uniqueness for information science lies in the theoretical way of *organizing* the world of objective knowledge *for intellectual use* by World 2 – well aware that World 3 almost totally originates from individual, subjective knowledge. Brookes' interpretation of Popper's ontology gave rise to discussions among information scientists for several years[44,45].

Another valuable and well known interdisciplinary contribution, mainly from information scientists themselves, is the proceedings, edited by A. Debons, of the Third NATO Advanced Study Institute held at Crete 1978. The title: *Information Science in Action: System design*[46] indicated the progress achieved in the field to that date. The conference viewed information systems and their design in a context of information science. There were essentially four major focal points: 1. examination of the understanding of the meaning when talking about the design of information systems; 2. ideas about the knowledge about information systems and their effectiveness; 3. examination of the systems' impact on people and institutions, e.g. regarding issues of privacy, copyright, censorship; 4. problems concerned with the human resources that are critical to the design of information systems. The collection of papers include reports of empirical investigations and theoretical contributions pointing to future developments up to the eighties. Along the same lines and at the same time but with a wider scope, C. B. Griffith edited a collection of key-papers in information science[47].

Finally the author wants to point to a significant publication, edited by F. Machlup and U. Mansfield[48]. It provides in-depth interdisciplinary analyses of approaches to information, as well as foci and scopes with respect to various disciplines, such as cognitive science, computer science, library and information science, linguistics, cybernetics, information theory and systems theory. Further, each discipline attempts to relate to information science. This highly communicatively designed publication, produced from 1980–83, put information science into perspective.

The publication includes two contributions to what information science should do and should not do, by J. H. Shera and M. Kochen, both highly distinguished scholars. Shera's analyses focus on information science from a librarian's point of view whilst Kochen discusses the field from an information science approach. Shera advocates the establishment of a scientific discipline mainly dealing with "symbolic interaction", also called social interaction.

He outlines a scenario in which information science operates on theory-level, seen as the theoretical foundation to librarianship. He looks upon the field with the *social rôle* of the library profession clearly in mind, denouncing both the "marking and parking" syndrome typical of document retrieval in libraries, and the computer and data-driven nature of information science in that period. However, Shera does not talk about "information". His idealistic view, or hope for the survival of the profession, is hardly operational – more associated with library science than information science.

Kochen, from this point of view, is more straightforward. He finds it fruitless to engage in semantic disputes over when the discipline of information is not epistemology, psychology, biopsychology, and so forth. "What matters is that investigators who identify with the information disciplines, formulate researchable problems and make discoveries, and contribute insights that clarify the nature and dynamics of information and knowledge"[49] (p. 371). Like Shera, he disapproves of librarianship, library science, documentation, and information science understood in a narrow sense, i.e. focussing solely on written records and the physical documents and processes. From a more psychological view he defines information science in a broader sense, concerned with the information, knowledge, and understanding, i.e. essentially with *meaning* as perceived by a receiving mind and embedded in such physical entities.

5. The scope and current state of information science

The formulation of the problem and the phenomena information science hopes to solve is of basic significance. It is through the establishment of this problem that the precise area of systematic, scientific investigation can be specified, and the assumptions governing that activity developed. Drawing upon previous statements by Wersig and Neveling[16] and Belkin and Robertson[50], N. J. Belkin formulates that problem to be[2] (p. 58):

> Facilitating the effective communication of desired information between human generator and human user.

The statement originates from Belkin's doctoral thesis[1] (p. 22). In the author's opinion, the crucial notion is *desired information.* We are here explicitly speaking of a purposeful wish for information by a user. The emphasis is on the quality of the interaction between generators and users of recorded information.

The statement implies the study of the user's *reasons* for acquiring information, recorded in systems of various kinds, the processes of *providing* desired information to users *qualitatively,* and the processes of *use* and *further generation* of information. We are dealing with *all kinds* of users as well as knowledge levels in these processes which basically involve all types of means of recording. Information science is consequently limited to studying specific phenomena of communication, not all communicative processes on a meta-level, as suggested by Debons and Vickery. Neither should it concentrate solely on the means of recording and communication, e.g. information technology applications.

Belkin outlines five areas of concern for information science, based on the problem statement formulated above[2] (p. 58):

1. [transfer of] information in human, cognitive communication systems;
2. the idea of desired information;
3. the effectiveness of information [systems] and information transfer;
4. the relationship between information and generator;
5. the relationship between information and user.

Ingwersen[51] points to these five major areas of study, and in collaboration with Wormell develops their substantial impact on information science[52].

The first area deals mainly with formal and informal transfer of information, for instance scientific communication or information flow within institutions. The second area seeks to understand the generation and development of needs for information, within society, among specific groupings of people or individually. It is the nature of and reasons for desired information which is the focus of attention, those reasons being problem solving or fulfilment of cultural, affective or factual goals.

The third area studies methods and technologies that may improve performance and quality of information in information systems. Further, this

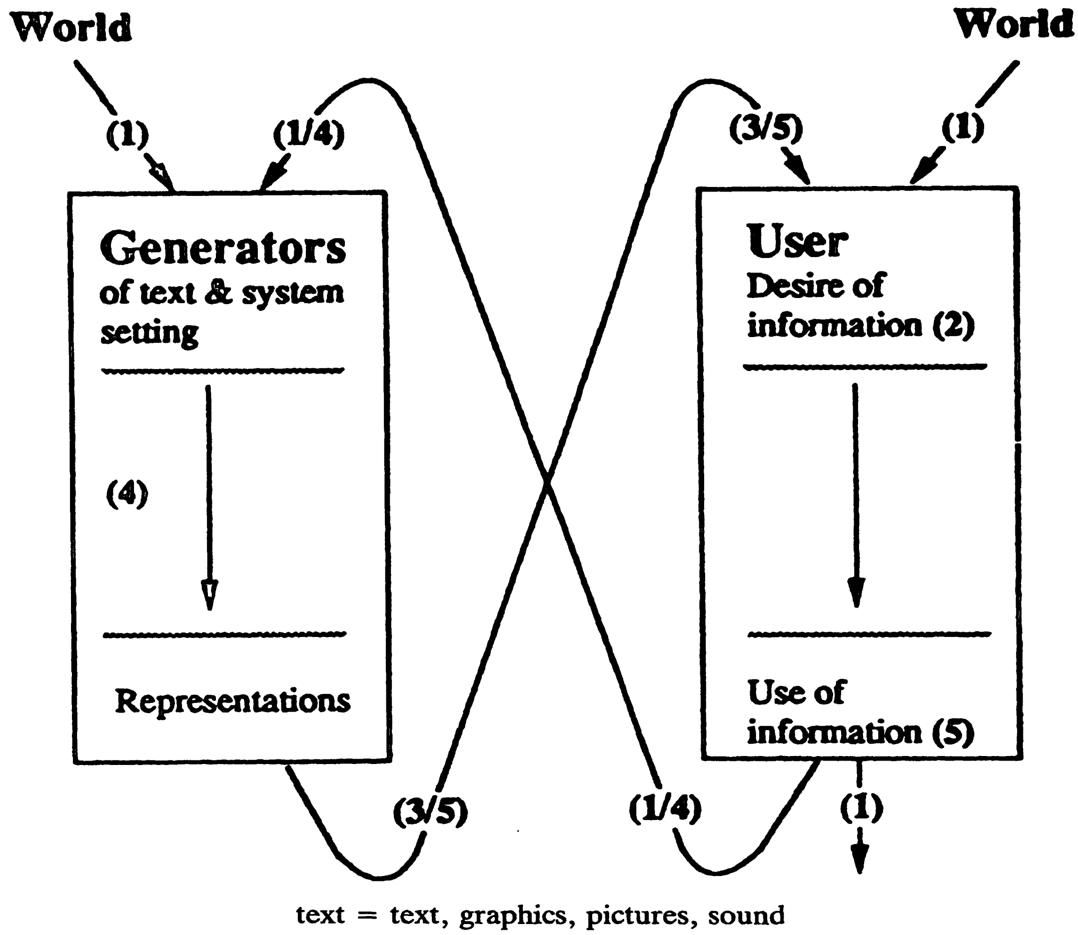

Fig. 3. Major areas of study in information science. Numbers in () refer to the five areas.

area is concerned with the development of theories and ways to ease the transfer processes of information between generators and users. The area is closely linked to the fourth area of concern which deals with generated knowledge and forms of its analysis and representation in (text) information systems. Here we find theoretical and empirical approaches to indexing and classification, as well as theories concerned with measurements and distribution of R & D production. The fifth major area of study has its focus on the relevance, use and value of information.

Belkin's problem formulation and areas to study are attractive, exactly because of the explicit statement of foci for present and future research, demonstrating both sociological and individual psychological dimensions. Debon's suggestions of interactivity between generation, communication and use of "states" as well as Shera's much more social approach to information interaction and transfer are made operational.

The five major areas, illustrated in the two-dimensional Figure 3, may be studied separately or in combinations. In the author's opinion they form a framework within which information science develops important sub-disciplines:

Informetrics, i.e. the quantitative study of the processes of (written) communication, such as co-citation in bibliometrics, is mainly concerned with the areas 1 and 4.

Information management, incl. evaluation and quality of textual a.o. media-based information retrieval systems, is basically concerned with the areas 3 and 4.

Information (retrieval) systems design belongs to the areas, 3, 4 and 5.

Information retrieval (IR) *interaction* is fundamentally concerned with the study of information processes in the areas 2, 3 and 4.

In Figure 3 the arrows refer to relations between or within generators and user associated with the processing and transfer of information. Numbers in brackets refer to the study areas described above. To the left there are the generators of texts as well as system features and their forms of representation in (text) information systems [4], e.g. in the form of database structures and indexing terms. To the right the user may transform his desire for information [2] into a solution and use [5] by obtaining relevant information from a system [3/5]. Below to the right the user may decide to become generator and communicate something to the world [1], for example as author of text or pictures[1/4]. The user and generators may communicate with, and be influenced by, the world around them [1].

In the author's opinion, research and development work carried out since the end of the seventies in information science demonstrates the validity and actuality of these major study areas as well as the outlined sub-disciplines.

To summarize what seems to form the kernel around which information science currently is developing and to demonstrate its new challenges one may point to certain trends, made visible during the very recent CoLIS Conference on Conceptions of Library and Information Science[53]. They are all strongly connected to a more *human-driven approach* to information transfer.

There seems to be a strong overall trend characterised by a move of research interest from access-orientation towards accessibility *and* use of stored knowledge or knowledge representations. This may reinforce a rather *holistic* approach to all the areas in Figure 3, in particular the areas 1, 3 and 5.

The scope of information science expands at present into society and the discipline is reaching a *critical junction* in its evolution, in line with other fields such as computer science, informatics and the cognitive sciences[70]. This move thus entails far more interest in the use and transformation of information into knowledge on both individual and societal level, i.e. the areas 1 and 5. A central challenge ahead is to define and to make operational contemporary *effectiveness criteria* for the purpose of evaluation. This implies the replacement, or at least the extension, of relevance and utility by functional use, quality, selectivity and strategic importance assessments, i.e. the areas 3 and 5.

The following specific trends are demonstrated during the last decade in information science R & D literature as well as during recent conferences and workshops, pointing to the future:

1. a strong requirement for making the technology fit the human being;
2. a shift from focussing on "documents" and "text" to aiming at "information" transformed into "knowledge" by means of all conceivable media;
3. a shift from understanding information as purely scientific towards "information" understood in a broad sense, as a critical and strategic asset to society;
4. no separation of "accessibility" from "use" – but viewing these processes in conjunction.

Concerning the trends 1–3, the background for these changes is recently argued by Wersig, by introducing the concept of *knowledge for action* by actors[68]. Knowledge for action follows up Saracevic's historical views[70] and signifies an extension of Wersig's earlier work on the reasons for desire for information[3,4], further discussed in section 6.

By placing the focus on the human sphere (trend 1) as well as on transformations of information into knowledge via a multitude of media (trend 2), and dealing with a wide range of information types (trend 3), the *intentionality* behind and use of such transformations becomes of crucial importance to information science. The emphasis on knowledge for action by actors implies that an important reason for a desire for information is to obtain knowledge in order to perform some kind of mental action or task activity in organisational and other social environments. Such reasons do not have to be confined to problem solving issues, but may in addition involve cultural and emotional goals or interests.

These trends walk hand in hand with the focus on "accessibility *and* use" (trend 4). This issue clearly involves what has been worked on up through the 60's and 70's and which is under rapid development at present: the problems of technology applications and the modelling of information processing and retrieval. The challenge is that one now has to deal with such rational matters in a holistic fashion, achieving a realistic balance between technology and man. Hence, the recent expression *information ecology*.

Since information science in future will have to deal with both quite different social groupings, systems and domains as well as the individuals forming such environments, it must consequently take into account the *information interaction* that occurs – not only between specific systems and man, but also among individuals in a social context.

This highly complex scenario introduces a certain degree of *uncertainty*. It implies that the classic striving for a complete understanding of how the world works becomes a rather enigmatic venture. It becomes profoundly uncertain which elements of various types of information inherent in a both highly structured and virtually unstructured world of potential information that may be of most strategic importance to often vaguely defined intentionality underlying often ill-defined requests for information – information that finally is supposed to become usable knowledge for action. However, one must not overlook that information science is concerned with *stored* potential information. Hence, present and future theory building in information science will have to introduce and consider *dynamics of information* in order to meet the demands from a rapidly changing world of actors.

6. Understanding information in information science

The major areas of study as well as the current trends demonstrate that *information* must be the central phenomenon of interest to information science – given that the key problem is "facilitating the effective communication of desired information between human generator and human user". Therefore, there should be some generally agreed-upon *concept of information* appropriate to that problem.

Prerequisites for such a concept for information science are that it is relevant to the five core areas of study, must be related to knowledge, is definable, and operational, that is generalizable, i.e. not situation specific, and offers a means for the prediction of effects of information. The latter implies that we are able to compare information, whether it is generated or received. Hence, we are not looking for a definition of information but an understanding and use of such a concept which may serve information science and does not contradict other information-related disciplines. The major study areas and the problem statement show that communication processes play a fundamental rôle, involving sender, message, channel, and recipient. The special case for information science lies in the notion of *desired information* and that the messages mainly, but not always, have the form of *text*, somehow organized in a system. A relevant information concept should consequently be associated with all components in the communication process.

Often, however, understanding of information is associated with one or two, but not all of the components, hereby reducing their relevance to information science. G. Salton[54], for example, identifies information with *text contents*, represented by the words or index terms. Although a user may be allowed to provide relevance feedback, stating whether a document or text is relevant or not, this fact does not indicate any notion of effect on the user, only on the system. Neither does it provide any social communicative context. Salton's interest lies in isolating generated messages (texts) conveyed by signs (words and other attributes) in organized channels (text information systems), in order to establish mathematical theories in relation to (text retrieval) systems' performance.

Yet more limited in scope but underlying Salton's view is Shannon's rational information concept, which, to be more accurate, originally was a measure of probability, forming part of his mathematical theory of communication[19]. The measure is concerned with the probability of the reception of messages through a channel, explicitly *not with the semantic aspects* of messages. Shannon's information measure concept is rather difficult to apply to the entire context of information science where meaning in general is related to information. Notwithstanding, S. Artandi[55] and M. F. Lynch[22] have attempted to make use of Shannon's information measure. Artandi assumes the measure to form the basis for two other understandings of information, each related to different components in the communication process.

One approach adheres to semiotics, i.e. essentially to meaning, the other views information as a means to *reduction of uncertainty*. In these three understandings of information Shannon's information measure plays its original rôle, being restricted to the functions of non-semantic encoding, transmission, and decoding of messages or texts. Although the three approaches to information are all concerned with communication, they seem only applicable to information science by viewing its research areas isolated from each other, using different understandings of information for each purpose. For instance, while it is clear that reduction of uncertainty is a relevant concept in the study of recipients (users) and their reasons to desire information, it becomes unclear how this understanding of information may be related to generation processes.

With Salton, Shannon and Artandi, the focus for a concept of information has moved from the areas of generated messages (contents of texts), over the message itself (not its meaning), to its meaning (e.g. to recipient or sender), and ending in the form of reduction of uncertainty in the mind of the recipient.

Also G. Wersig devotes attention to a concept associated with the *reduction of uncertainty* or doubt and the *effect* of a message on a recipient. In a very careful and profound examination of the communication process he categorizes various information concepts and develops his own[3]. His analysis suggests that it is difficult to see information only as a change of an individual recipient's state of knowledge, since it may be impossible to characterize or determine a state of knowledge as such. Instead, Wersig narrows his concept of information to associate with a reduction of uncertainty which for information science implies reduction of uncertainty by means of the communication processes. Uncertainty (or doubt) is the end product of a problem situation, in which knowledge and experience may not be sufficient in order to solve the doubt. It is important to note that information is associated with knowledge through the event of reducing the uncertainty, but also, just as for Artandi, this concept of information may deal only vaguely with the senders' states of knowledge. Slightly later, but relatively unnoticed by Belkin, Wersig extends his information concept and his communication model to include the *meaning* of the communicated message in order to explain the effect on the recipient, reducing uncertainty[4]. In this concept a message "has meaning", and may "give meaning" to the recipient.

However, Wersig's extended information concept does not explicitely incorporate the sender's situation. Belkin's argument[2] against Wersig's 1971 information concept as to its concentration exclusively upon the recipient still holds, but is less powerful. Similarly, Belkin's argument, that Wersig's original concept is situation specific and not generalizable loses some weight.

This problem of exclusivity can only be dealt with by extending the concept to include the entire communication process. This has been attempted by Brookes[34,5,14], Belkin[2], Machlup[15] and Ingwersen[6] and will be discussed below.

The author wishes to emphasize the importance of Wersig's analyses, because it points to *reasons* for requiring information through communication with external sources, the "state of uncertainty" or doubt being this reason, in the context of a problematic situation.

Secondly, the "problematic situation", i.e. what is known by the recipient to be a *choice between possibilities* of action, of solutions to problems, or fulfilment of factual or emotional goals (author's interpretation), is the *problem space* which may be transformed into a state of uncertainty. This latter state can then be seen to be identical to the notion of the "anomalous state of knowledge" (ASK), defined by Belkin[1,2] to be the "recognition of an anomaly by the recipient in his/her state of knowledge" which can only be solved by communication, for example by interogating an information system. The transformation in "problem space" into a "state of uncertainty" eventually takes place when a person cannot solve a problematic situation or fulfil a goal by himself by thinking.

In his critical essay on the semantics of information, published as an epilogue to his book referred to earlier, Machlup follows similar lines of principle as does Belkin concerning the importance of the sender in the communication processes. In addition he provides a definition of the concept of information in communication, broader than Wersig's but useful in its distinction between information proper and "metaphoric information". He states[15] (p. 657):

> Real information can come only from an informant. Information without an informant – without a person who tells something – is information in an only metaphoric sense... information is a sign conveying to some mind or minds a meaningful message that may influence the recipients in their considerations, decisions, and actions.

He points to C. Cherry who states that "all communication proceeds by means of signs, with which one organism affects the 'state' of another"[56]. Cherry also considered the question of how to distinguish between communication proper, by the use of spoken language or similar empirical signs, e.g. text, and other forms of causation, e.g. electrical effectors. It is in the latter sense that Machlup recommends the notion of information as a metaphor.

This understanding of information clearly distinguishes between the linguistic level (signs) and the semantic level of a message and relates information to the recipient's knowledge state providing clues as to the possible effects or use of information: considerations, decisions and/or actions taken by the recipient. In addition, we are allowed to use "information" (metaphorically) when speaking of causations within machines.

Like Wersig's extended concept, Machlup's definition does not inform about what information really is, as seen from the generator's point of view, except that it is "something", e.g. signs conveying a meaningful message. Obviously meaningful to the recipient and supposedly meaningful to the informant.

With Wersig and Machlup we have a rather profound understanding of the *reasons* for the desire for information, the eventual *effects* of information on the recipients' knowledge state and a *distinction between the linguistic and the semantic levels* in the communicated messages. Machlup does not seem influenced by either Belkin, Wersig or Brookes, although the latter is referred to, but on different issues.

N. J. Belkin makes a similar distinction between levels of communication, as does Machlup. In his critical review article from 1978 he suggests and

GENERATORS	→	TEXTS	↔	RECIPIENT

The Linguistic Level of the System

STATES OF KNOWLEDGE	→	INFORMATION	↔	ASK

The Cognitive Level of the System

→ Transformation
↔ Interaction

Fig. 4. The communication system of information science by Belkin[2] (p. 81).

argues an information concept explicitly based on a *cognitive view* of the situation with which information science is concerned[2] (p. 80). His model of the communication system of information science derives from his Doctoral thesis[1] (p. 111) and displays two levels of *interactivity,* Figure 4.

Information is here seen as a structure and Belkin proposes that:

> the *information* associated with a text is the generator's modified (by purpose, intent, knowledge of recipient's state of knowledge) conceptual structure which underlies the surface structure (e.g. language) of that text[2] (p. 81).

He argues that this information concept satisfies all the prerequisites outlined above by linking it to the idea of structure within an analysis of the communication system that is of interest to information science. He takes "that system to be a recipient-controlled communication system, instigated by the recipient's anomalous state of knowledge (ASK) concerning some topic" (p. 80).

The "recipient-control" serves to include the important notion of desire for information, and Belkin is right in claiming his concept to be satisfying. It is related to states of knowledge of both generators and recipients in terms of structural representation and it takes into account an effect, by solving the anomaly in the recipient's ASK.

However, it is somewhat unsatisfying that the concept in its verbal description emphasizes the generation and then relies on the context of the communication model. Belkin's own arguments in relation, for example, to Wersig's original information concept are merely based on its verbal part and do not take the model into account. Likewise, we must assume that the effect on the recipient's state of knowledge exists. The effect is neither expressed in the model nor in the concept statement. In addition, one may doubt that generated texts always are structured according to specific "knowledge of (one) recipient's state of knowledge". Instead, a generator may be said to have a model or general idea of a group of *potential recipients' states of knowledge* in mind. The concept "anomalous state of knowledge" is, as stated above, very identical to "state of uncertainty", and similar to D. M. Mackay's notion "a certain incompleteness in his (the user's) picture of the world, an inadequacy..."[69]. "Uncertainty", "incompleteness" or "inadequacy" seem to have more accurate connotations as to the user's situation than the vague term "anomalous". However, the acronym "ASK" is, of course, of a more powerful nature, than e.g. USK or ISK.

In relation to prediction Belkin himself argues that "because both the information and the recipient's state of knowledge are considered as structures, and because the information structure is derived from a knowledge structure, the effect of the information associated with any particular text can be predicted, *given some idea of the recipient's state of knowledge, and some means for representing state of knowledge*"[2] (p. 82) (emphasis by the author).

This argument relies, quite rightly, on the *notion of structure* related to all components participating in the communication process. However, is it possible to have an idea of a state of knowledge and representative means? Wersig doubts it. In the author's opinion it is possible to have a (general) idea of a group of recipients' state of knowledge, or better, deliberately to induce a specific and controlled "problem space" or a "problematic situation", creating a "state of uncertainty". In such experimental cases the resulting effects on the recipients (considerations, actions taken, etc.) represent parts of the state of knowledge which can be analysed. Controlled empirical investigations have been carried out by C. W. Cleverdon et al. in relation to (human) indexer consistency[57] and by Ingwersen in relation to librarians' search procedures and use of search concepts[58].

What is not possible is to have an exact idea of several states of knowledge, nor to predict individual effects. This is a problem of *uncertainty* inherent in the cognitive approach to information.

6.1 The consolidated information concept

The author's proposal for a concept of information for information science is based on the cognitive view, as defined by M. De Mey[59] (p. XVI):

> any processing of information, whether perceptual or symbolic, is *medi-*

ated by a system of categories or concepts which, for the information-processing device, are a model of its world.

The viewpoint stresses the rôle of the *actual state of knowledge* (categories or concepts = world model) in the information processing device. This may be human or machine. For a recipient in a communication process this view implies that if a message cannot be mediated by his state of knowledge, no information processing takes place. Consequently, if the recipient cannot *perceive* the message, although he wishes to do so, information is reduced to the surface structure, Figure 4, i.e. to data (text or signs). This approach is reflected by P. H. Lindsay and D. A. Norman[60] and P. Johnson-Laird and P. C. Wasow[61] among others. For further discussion of the cognitive view and its relevance to information science and retrieval, one is referred to Ingwersen[62,71].

Ingwersen has analysed the implications of the cognitive view for information processing and retrieval, discussing B. C. Brookes "fundamental equation" for information science[6] (p. 465–471). Actually, this "equation" has been displayed in several forms during the period in which Brookes developed it. Belkin[2] refers briefly to it and Zunde and Gehl[23] reject it completely as being non-operational.

The "equation" for information science has normally had this form[14]:

$$K(S) + \delta I = K(S + \delta S) \quad \text{(a)}$$

which states in its very general way that the knowledge structures K(S) are changed into a new modified state of knowledge K(S + δS) by the information δI, the δS indicating the effect of the modification. Brookes states[5,14] that its expression is in pseudo-mathematical form because this is the most compact way in which his idea of information can be expressed. We may therefore see it as a model. He stresses that although his terms and symbols are not defined, the equation implies that if its entities were measureable they would have to be measured in the same units, i.e. that information and knowledge are of the same kind and have the same dimensions. In 1977 Brookes' equation has a more dynamic form[5]:

$$\delta I + K(S) -> K(S + \delta S) \quad \text{(b)}$$

Approximately at the same time as Belkin[1], and slightly before[2] in 1978, Brookes stated in 1977[5] (p. 197):

1). Implicitly it (the equation) offers a definition of *information as that which modifies what is denoted by K(S),* which is a *knowledge* structure.
2). It implies that the information [δI] is also structured.
3). Knowledge structures can be either subjective or objective (recorded).

He regards knowledge as a structure of concepts linked by their relations, and information as a small part of such a structure. The reason for statement 3) is that he regards recorded K(S) as Popper's World 3 (objective knowledge). By deliberately not substituting δS for δI in model (a) and (b) the notation emphasizes that the same δI may have *different effects* on *different knowledge structures,* i.e. implying subjectivity[14].

Consequently, one may understand model (b) and the points 1) – 3) as concerning both the generation *and* reception of information in such a way, that a state of knowledge is *transformed.* Unfortunately, Brookes does not follow up this line of interpretation of his own model.

Ingwersen[6] (p. 470) bases his understanding of information on this dynamic aspect of the model and extends it explicitly to include generation. He states:

> Concepts are defined by Gowin as "perceived regularities in events or objects as designated by a sign or symbol"[63]. One may therefore suggest that Popper's World 3 – the world of objective knowledge[41] is "potential information" consisting of generated beliefs, intentions, ideas, theories... in the form of (objective) conceptual knowledge structures... When World 3 is *accessed* (one opens a book) the "potential information" is data in the first place. The data is communicated designations, i.e. signs, symbols, words, text... that contain what R. C. Shank calls meaning and inference[64].
>
> In the event of *perception,* the data is transformed by the actual K(S) into information omitting non-perceptable rest-data. Some potential information, however, does not represent new knowledge. Concepts and concept relations may be recognised, being previously stored in the memory. It is the new information that may transform K(S) or act as a clue to modification. How δI affects K(S) depends on the state of knowledge of the individual and the complexity of the information perceived. ... IR systems receive similar data from the searcher. The system's information processing in model (b), however, follows a slightly different pattern. δI is reduced to solely recognised designations. Consequently, when rejecting non-recognised signs (= rest-data) present IR system's K(S) remain the same. However, they may *look*

intelligent and perceptive, exactly because they display stored, objective knowledge structures containing ideas of searcher behaviour.

The important notions for information science in this understanding of the communication and information processing are: 1. viewed from the recipient the information is a potential until perceived; 2. viewed from the generator the recipients are likewise potential; 3. when in a "state of uncertainty" a recipient accesses the potential information it becomes data which *may become information* if perceived; 4. if not perceived the potential information remains data for that particular recipient and potential information for other recipients and generators; 5. the perception is controlled by the actual knowledge structures (K(S)) in the recipient's actual state of knowledge and problem space; 6. the information (δI) may infer (support) the uncertainty state and transform the problem space and the state of knowledge, causing considerations, decisions, actions, intentions, change of values... (effect); 7. information is a transformation of knowledge structures.

Brookes' model (b) may be displayed in a modified form which includes generation (variation of Ingwersen[6] (p. 468)), given that generated and accessed potential information (pI) is perceived by a recipient:

$$pI -> \delta I + K(S) -> K(S + \delta S) -> pI' \qquad (c)$$

In (c), of potential information pI is perceived the information δI, which is *mediated* by the actual knowledge state (including the "problem space" and "state of uncertainty") K(S), transforming the state of knowledge into a new state K(S + δS) with the effect (δS). The modified state of knowledge may *generate*, e.g. answer back or later create, new information (pI'), potential to other recipients.

In view of the arguments stated above, Belkin's model, Figure 4, may be extended to incorporate the "problem space" and the "state of knowledge" of the recipient and replacing ASK with the "state of uncertainty". In Figure 5 the recipient's actual state of knowledge may be transformed into a situation-specific state of mind – a problem space – in which the individual recognizes his/her lack of knowledge, e.g. in order to choose between possibilities for action, between solutions to problems, or in relation to the fulfilment of factual or emotional goals. If not capable of filling this problem space by thinking the individual's state of mind may end up in a "state of uncertainty", which may be reduced by information through interaction with the world around it, e.g. by accessing an information retrieval system. The reduction may happen via a transformation of "state of knowledge".

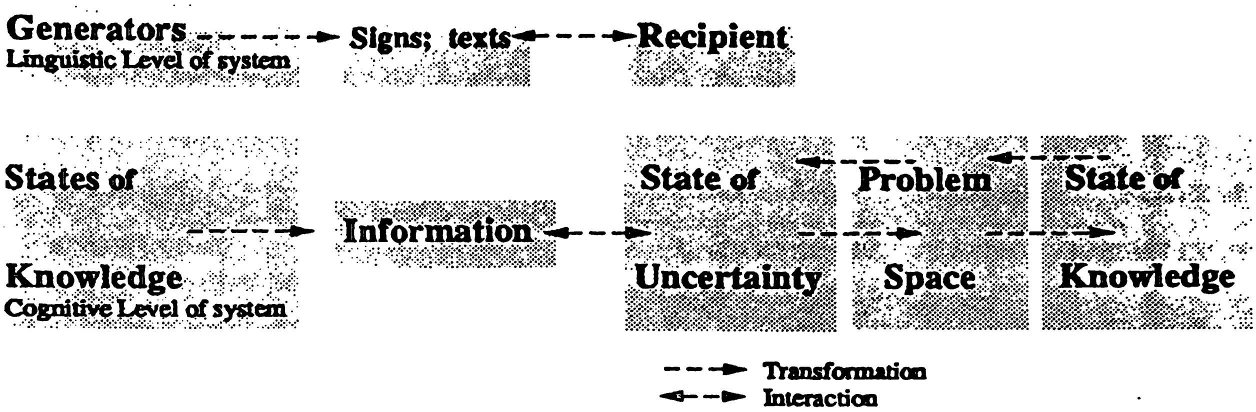

Fig. 5. The cognitive communication system for information science[62] (p. 18).

The concept of information, from a perspective of information science, has to satisfy dual requirements:

On the one hand information being

the result of a transformation of generator's knowledge structures (by intentionality, model of recipients' states of knowledge and in form of signs);

and on the other hand being something (a structure) which

when perceived may affect and transform the recipient's state of knowledge.

Inherent in the notion "perceived" is intentional causation, expectation and thus *desire* in relation to accessing the (recorded) world around the recipient. Signs will mainly take the form of text, including graphics and other linguistic means of communication in a multimedia environment. Intentionality is understood as stated and argued by J. R. Searle[65], (p. 15), i.e. that "all valid teleological explanations are species of explanation in terms of intentional causation".

This concept of information satisfies all the requirements stated previously. It draws on a wide range of sources, does not contradict more broad understandings of information at the interdisciplinary level, and it is related to other information concepts, including in information science, state-change concepts such as Debon's[37], Wersig's[3,4], Farradane's[36], and Kochen's[49] and structure-based concepts such as Brookes'[34,5,14] and Belkin's[1,2]. It takes into account the rather dubious criticism by C. J. Fox of Wersig's recipient-oriented information concept[72] (p. 41–61).

From outside information science, Machlup's (and Cherry's) concept is very similar in many respects, being based on the representation of meaning, change of state, and effects[15]. The concept is associated with N. Bjørn-Andersen's information concept, developed in relation to decision-making processes[66]. By introducing the concept of *premiss* – defined as *that* information, in relation to an actual decision, which is received, perceived, influencing the decision-making process, and affecting the recipient's state of knowledge – he also emphasizes a cognitive and pragmatic approach to information processing and transfer.

7. Implications of the information concept

This understanding of the concept of information in information science is fundamentally associated with *human* communication of *recorded* potential information, processed by generators as well as recipients.

Only when the dual requirements are satisfied in a space/time continuum we may talk of *information* – in a real sense. Since the communication system is user instigated, it is apparent that real information only can materialise when all the conditions embedded in the second requirement are satisfied, that is, at the moment when the generated potential information is received and perceived, affecting *and* transforming the recipient's state of knowledge. The operationality of the concept exactly relies on the fulfilment of these three conditions. By transforming the recipient's state of knowledge, information turns into knowledge – as matter may convert into energy, metaphorically speaking. In order to *measure* any kind of perception, and the further steps in the cognitive development process, the recipient must be turned into a generator's rôle, producing a response.

7.1 Implications for information science

Research into how and why this transformation occurs may hence only take place during some kind of *interaction*, for example between a system and a person who turns into being a generator who creates a response by communicating potential information back to the system or to another person. The response forms the basis for measurement of perception, effects and transformations of knowledge. The previously mentioned investigations of indexer consistency[58] and studies of librarians' retrieval procedures[59] actually applied this type of research setting. For example, in the latter experiments all the librarians were given the same question. The nature of the question was such that it deliberately should induce a conceivable problem space and *uncertainty state* in the state of mind of each librarian. By means of the "thinking aloud method" applied during their search activities, i.e. their interaction with documents and system features, one is able to measure their ways of perception of information space as well as effects and conceivable transformations of their knowledge states. Certain patterns may emerge. For instance, all librarians are "persuaded" by the question to read (perceive) one and the same reference tool; some librarians overlook particularly potential information necessary for further retrieval (no effect), others grasp a potential segment of information (effect) and change their search tactics accordingly. At this point we may talk of *information* because a transformation of knowledge structures clearly took place. One may here refer to the Fundamental Equation, version (c), section 6.1. The conceivable transformation is qualitatively measured by the *linguistic manifestations* of new search paths and/or new search terms.

Two distinct limitations of measurement exist. 1. Certain behavioural but no, or only vague, linguistic manifestations are observed of the transformation. The person explicitly notices a segment of text (e.g. "this fact is interesting") and modifies his search procedure (e.g. switches database). The notification as well as the modification are observed. We are then sure that the potential information caused effect – and supposedly also became converted into information transforming knowledge. However, it is not possible to make a distinct assessment of that transformation. Hence, we are only measuring the effect on the state of knowledge – not the full impact of information. 2. Another case is that linguistic manifestations do occur (e.g. "this fact makes me remember X, so...") but no behavioural changes or new search terms develop (e.g. the recipient performs a loop). In such cases, the contents of the manifestation decides whether the perceived text produced a mental transformation in addition to an effect (e.g. verification of the already known) or no effect at all. At any rate the possible measure of information is definitively loose and unreliable.

From these examples as well as from the previous discussions of the variety of information concepts for information science, it is apparent that both the effect on and the transformation of the state of recipient's knowledge are *necessary conditions,* but only the transformation is a *sufficient* imperative for understanding information.

Hence it is evident that the information concept has implications for R & D work performed in the areas of interest as well as sub-disciplines in information science outlined above, section 5. Generally speaking, one will have to consider *all recorded results of transformation* of all the generators' knowledge structures that are involved in the communication process. Similarly, although far in space and time, at the communication event the various recipients' cognitive and further behaviour must be accounted for. The significance is to view both system features, such as dbs-structures, indexing rules and retrieval techniques, *and* conceptual structures, e.g. in form of text or images, *as potential information* – as results of generators' transformations of knowledge states.

As a consequence, without recipient instigated communication the so-called "information systems" are only data systems or "potential information systems" – or information systems metaphorically speaking. When subject to interrogation potential information is transmitted by a channel, e.g. by light, air, electrons, etc. During the transmission the potential information is reduced to structured data. When perceived by a human recipient data becomes once again potential information. At the point of transforming knowledge structures, its potentiality is made intelligible and it is information. Only at this instant is an "information" system a real information system. By integrating with the individual and actual state of knowledge through problem space and resolving the recipient's state of uncertainty – information converts into knowledge.

In short, we are constantly constrained to the linguistic level of communication, Figure 5, operating with potential information or data in form of signs, text, image, etc. during interaction. Solely at the moment of transformation of a recipient's state of knowledge the communication and interaction takes place at the cognitive level.

In *informetrics* this understanding of information implies more qualitatively based analysis methods than hitherto applied. The qualitative *cognitive impact* and nature of e.g. citations ought to be measured, not the common co-existence or cluster of citations in isolation. At least bibliometric analyses ought to incorporate the *weight of influence* of the citation, e.g. the frequency and direction of specific citations within a text.

In *information management,* in particular concerning evaluation criteria, the concept means to involve *functional cognitive impact and use* analyses, e.g. to assess how the functionalities of a user interface are perceived by users and transform their states of knowledge. Do they actually function properly in a cognitive sense, according to intent?

In *information (retrieval) systems design* the information concept forces designers to make systems more transparent than today and to create highly *adaptive and supportive* systems in order to improve their *informativeness*. Evidently, the concept does not allow us to view an information system as a mechanism that is capable of changing its own state of knowledge by itself. As stated previously, systems consist of transformed knowledge structures generated by man – i.e. potential information. Hence, when a system *receives* potential information in form of data from other mechanisms or humans it may perceive, i.e. recognize data which may cause effect. For instance, by touching the shift + PrtSc keys simultaneously the user makes the printer print out the screen contents on paper. However, no transformation of the printer's (or computer configuration) state of knowledge has taken place. Consequently, paper and digital or analogue computer-based information systems do not contain or process information, only data or potential information given by predefined rules and categories.

Similarly with respect to *information retrieval interaction*. So called "intelligent IR" does not and cannot exist according to the information concept. The expression "knowledge-based systems" (KBS) is far more adequate. Such systems do actually contain results of transformed knowledge structures. In contrast to man the KBS possess the advantage rarely to suffer from sudden loss of memory, once conceptual structures are stored.

However, the only *intelligent* participants in IR interaction are all the original generators of potential information organized in the systems as well as the person interacting with an IR system. At the IR event, only the latter individual may obtain *information* that may transform his state of knowledge. As a consequence of the cognitive view[59] as well as the derived information concept for information science only humans are capable of processing information at a cognitive level of communication, Figure 5.

7.2 Implications for other fields

The information concept may in addition apply to communication in general, speech understanding or archeology and other historical sciences in which various forms of transformations of states of knowledge form part of the study. Human communication by spoken language (or signs) is only of direct interest to information science when the purpose or result of verbal conversation is to access and use stored potential information. Similarly, mammals and other animals possess states of knowledge that may be transformed during their communication processes. Fundamentally, information science is *not* aimed at *making interpretations* or drawing up explanations of the surrounding world consisting of potential information. The field aims at providing qualitative means for others to make such interpretations.

Hence, information science is engaged in improving the *methods* for (re) organisation of and intellectual access to the stored potential information, in a continuous attempt to facilitate and support its usability to potential (human) recipients. The contents of the stored items, their message and meaning, their falsity or truth are only of interest in so far as their qualitative representation, accessibility, informativeness and use are concerned.

Often information science is associated with machine translation. It is not infrequently believed that if that field succeeds in its venture we may similarly succeed in our research on information transfer. In machine translation the attempts are to understand messages, i.e. to grasp their meaning by means of semantic analysis, and to transfer the meaning into another language. Naturally, a certain overlap of interests exists between the two fields and the information concept is pertinent. The aims of both fields may indeed look rather similar but the resemblance is superficial. Machine translation interprets meanings. Meanings carry information potential to persons. Hence, information science goes *beyond meaning* and aims at providing information which ultimatively is dependent on the *actual user's interpretation* of meaning in the situation.

The nature of information thus seems quite straightforward when we are dealing with artefacts, such as books, clay tablets, computers, buildings, etc. that intentionally carry text, signs, symbols, etc., generated by states of knowledge.

At least two other forms of "information" exist, however, fundamentally distinct with respect to their nature from the information concept discussed so far. These forms are:

a. *sense-data;*
b. *information, in a physical/biological sense;*

By application of the dual requirements and their imbedded conditions as a framework for a brief discussion one may understand the connections of the two concepts to our concept.

Within this framework *sense-data* is a proper designation for what seems to happen when a person receives and (un)consciously perceives physical evidence of the surrounding world. What is received is data in some form – not information. This corresponds to the fact that the first requirement of the information concept for information science is not fulfilled. On the part of the sender no knowledge structures exist, there is no intent and no knowledge of any recipient. The only remaining characteristic is the form of the randomly conveyed particles of energy or matter: they may take the form of structure. Remaining elements of the second requirement are at most reception, perception and conceivable effects. Very often not even perception will take place. As a consequence, the sensed "something" is data – and remains data.

One question is: may such data never become information in a real, not a metaphoric sense? The answer is yes, if data takes part in a communication event which includes intentionality, since data then will take the form of signs: a dog barks at you – and you turn away. Another situation is that a recipient receives sense-data (something burns him) and based on its effect he *chooses* to find out if the pain may happen again. This experimental situation is quite interesting from the point of view of our information concept. The recipient turns into a generator and "forces" a communication to happen by intent, by possessing knowledge or a model of the burning object and of the recipient (himself), and in form of a sign (i.e. the heat may or may not burn him again). As recipient he possesses a desire for that information and certain expectations. The sense-data may hence convert into potential information, affect and transform his knowledge state, thus being information at that moment. In principle, this was what happened to M. Ventris with Linear B.

This way of understanding sense-data is closely associated with the second type of "information" (b), applied in physics and biology. The experimental situation described is identical. By observing the movements of particles or stars the researcher obtains (structured) data. When he enters the data, hypotheses, theories, calculations, etc. into this work station, he definitively transforms his current state of knowledge into stored potential information and is definitely within the sphere of the information concept for information science.

A final use of the concept "information" adheres to a particular conception of the meaning of signals (or codes) within the field of General Systems Theory. If one accepts that communication between social and socio-technical systems involves information in a real sense, then one might be tempted also to consider the *influence* of other quite different systems on one another to be caused by information transfer. Such systems could be purely biological systems like the blood circuit, DNA-structures or the brain, or physical ones such as solar systems or the universe.

In view of the discussed information concept for information science the premiss for such considerations is only partly true. Indeed we may often talk of real information transfer within social and socio-technical systems, but rather more often we actually use the term in a metaphorical sense. For example, the transmission of communicated messages consists of data, signs, signals – not real information – but often albeit named "information" metaphorically speaking. In addition, the analogy between socio-technological systems and bio-physical systems is only an analogy, and the assumption of the "information" nature of influence that occurs between the various systems is consequently mis-interpreted. Therefore is the entire construct that e.g. DNA-molecules "carry information" or that fotons "inform" other particles rather out of proportion. DNA-molecules have only intent, knowledge of a recipient cell, etc. if one adheres to believe either in the existence of some kind of divinity or in a "blue-print" pre-established by nature. The codes or influencing forces always remain "data" in our sense.

At present T. Stonier represents this synthesis approach, attempting to define a universal theory of information, matter and energy[73]. In view of the information concept he tends to mix a cocktail of data, information, knowledge, carriers of messages, forces, influences, transformation, effect, and so forth – mainly at a metaphoric level. However, quite correctly, Stonier gives rise to an interesting problem on the borderline between the cognitive sciences, including information science, and the bio-physical sciences. Since "brains cause minds"[74] the question is: in which way do the physical laws, quant-mechanics, the properties and functions of the neurons of the brain, and the information-knowledge-thinking-cognition processes of the mind intercept with one another?

8. Concluding remarks

Currently information science seems to keep on the right track. Fortunately perhaps, for the sake of developments in the field, certain critical junctions await ahead. Questions about the influence of society on information transfer – and vice versa – and thus the future rôle of our field will have to be answered. In addition, qualitative and operational evaluation criteria must be developed and tested, and far more holistic and cognitive approaches to experimentation and theory-building should be applied in the nineties. With a more human driven and supportive approach to information transfer and because information increasingly becomes a crucial strategic asset at all levels of society as well as for reasons of information quality amelioration, information science must necessarily involve more elements of interpretation of uncertainty on several levels than done hitherto.

The understanding of information for information science suggested by the author and based on a cognitive view of information processing of man and machine is an attempt to underline the limitations – but also the vast flexibility – of our field. Its potentiality to society is increasing, hopefully also its future results.

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