Information Processing & Management Vol. 23, No. 1, pp. 33–43, 1987
Printed in Great Britain.

0306-4573/87 $3.00 + .00

INFORMATION SCIENCE AS INTERFACES OF THE COGNITIVE SPHERE AND SOCIETY

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(*Received* 20 *December* 1985; *in final form* 11 *July* 1986)

Abstract—Ideas from the science of science literature have been put within the framework of information science in a synthetic, critical assessment of information science philosophy. The information field is found to be in a transition state and the concept of its autocatalytic self-organization can be applied. Information science is expected to study preponderantly the ways by which humankind's cognitive creativity, with perpetually changing content, becomes humankind's everyday living force. Information science is likened to a membraneous system which takes active part in this transfer process both at the internal interfaces within the cognitive sphere itself and at the external interfaces between the cognitive sphere and the society at large. Examples of various types of information science membranes are given as possible research projects.

INTRODUCTION

Information scientists produce and read their own literature. That is the way scientific specialties usually grow, and become self-respecting and recognizable from other vantage points. For a field of inquiry like information, embracing in fact all the facets of human creative cognitive potential, the trails through literature are manifold, and frequently are faint; therefore they are likely to be discarded in favour of the more obvious pathways for literature wanderings. The choice will then depend on one's favourite conception of the meaning of information.

This essay grew out of readings in three subjects, at first sight not very closely related: (i) growth of science, (ii) science teaching and education and (iii) information science. No concrete interrelationship was recognized, nor was the goal of writing this critical synthetic literature review present at the outset. However, in the course of reading in the three literature areas, relationships were seen to be structured on the following premises:

(i) Current scientific development may still be undergoing an exponential upsurge, or a retardation period heralding a main paradigmatic change may be imminent; the present state of science may thus be likened to a rather sharp transition state. This may also apply to human civilization as a whole.
(ii) There is a need for a holistic approach to science teaching and to science education; it is accepted here that the self-organizing principle in transition states may be used in information science; another lead for information science may be accepted from science education, as it has been suggested that its research should primarily encompass and concentrate upon the science/society interface;
(iii) It is also accepted that the communicative and social substance of information is of paramount importance; therefore information science may be likened to a membranous structure connecting parts of the human creative cognitive sphere (the internal interfaces) and also connecting the latter with the larger society (the external interfaces).

A general strategy for information science orientation will be propounded here on the basis of (iii), with an operational definition of information science as a byproduct of the synthesis.

1. THE TRANSITION STATE

Zhao Hong-Zhou[1] used the expression "transition period", but "state" indicates the structural aspect of the change more appropriately for our discussion here. In a diagram depicting the "number of important achievements" in relation to time, from 1500 A.D. to the present, the author delineates two periods of "normal", i.e. exponential, scientific development: 1550–1670 and 1740–1930, ". . . but the seventy years between 1670 and 1740, serve as a transition period during which the curve is not an exponential. . . . There are various signs at present which show that the world may have entered again in a new unusual period. . . . Actually the period started as early as in the 1930's. . . . It is apparently an outcome of the revolution in modern science brought forth by the theory of relativity and quantum mechanics. If indeed this unusual period will behave like the previous ones then there might be an end to this downward tendency by the close of the century and then again a new advancing phase will begin. . . ."

In point of fact the present transition is questionable because in a recent paper[2] coauthored by Zhao, a similar diagram bears a serious note of warning that the drop of the curve in the mid 1900's resulted partly from lack of data for the last decade in determining the average value for the last 30 years' span, i.e. the average value of the 60s without consideration of the 70s value.

This uncertainty aside, there is another one, but probably less serious. Namely, the data from which the curves in refs. [1,2] were constructed was taken from the *Chronological Table of Natural Scientific Events* (published in Shanghai in 1975). One may infer from the title of this publication that it does not deal with the "soft" sciences; yet a number of achievements in the social sciences for instance have been evaluated[3] by others. It would be desirable to include them when tackling the possibility of an imminent transition state in scientific endeavour in general. They would certainly not alter Zhao's observation of the first transition period, as the social science data pertains to the period 1900–1965.

While a definitive quantitative conclusion as to an imminent transition state in the sciences is lacking there is qualitative evidence from various manifestations of the scientific process.

For instance, change is expected in scholarly publishing practices: ". . . to differentiate manuscripts along lines that may not have been as salient in the past as they might be in the future . . . Innovation is likely to become an issue of growing importance in scholarly publishing, given the *accelerated* expansion of knowledge and its increasingly *interdisciplinary* character . . ."[4]. (Emphasis here and below is the author's.)

As to the internal mechanism(s) of scientific *progress* a particularly illuminating discourse can be found in Ziman's paper [5]. His main point which is of interest here is that in contrast to the simplified picture of the whole of science advancing on a single common research front, there are hundreds of fronts and even more important, changing shape(s) at a significant rate. The whole of science is more like guerilla warfare rather than static, positioning warfare. The second point of importance here is that Ziman stresses that cross-fertilizing ideas surmount what nowadays appear to be artificial subject classification boundaries. The implications for information science especially are fundamental.

We must ponder whether information science itself, whatever it means at this point in the discussion, is a stable structure or not.

A documented review, diachronic at that, by Schrader[6] shows that, in spite of more than one conference per year (1948–1978) bearing the word "*Information*" in its title, no consensus as to the scope of the concept, let alone its definition, has been reached. Various terms—bibliography, documentation, information retrieval, information science, informatics, bibliometrics and related theoretical terms—all survived concurrently from 1895 to 1980, although there has been a shift in scholarly allegiance towards the last three since the 1960s.

Schrader's review article does not refer to a paper by Belkin[7] published five years earlier; the latter is to my knowledge the most systematic approach to a vast array of opinions and definitions. Moreover, Belkin's paper is a tenuous link with one of the conferences[8], since he chose several papers from it to match against his requirements of a concept

for information science. According to the Social Sciences Citation Index, Belkin's paper has met with continuous and predominantly positive response in the literature. The response itself, being rather a rare event in this sort of literature, suggests his paper is important.

However, a general lack of a proper polylogue through the published papers is just another sign of the amorphous structure of information science. This is corroborated, for instance, by a brief bibliometric analysis of *Perspectives in Information Science*[8], using three chapters (I, II and IV) which are more related than the others to the structure of information science. Altogether there are 21 papers giving 209 references, of which 174 were each cited in only one paper. Only 4 papers were cited in two articles and one ("Kuhn's revolution") in four. A group of seven *authors* had various papers cited in more than one of these articles. There was but one case of cocitation, in two papers from chaps. I and IV.

From the 174 uniquely referenced papers of the three chapters in ref. [8], only five authors (De Solla Price, Fairthorne, Hillman, Kochen and Rosenberg), and seven (Bar-Hillel, Carnap, Goffman, Morris, Parker, Paisley, Saracevic) from the multiply referenced group, were also authors in the 1970 reader *Introduction to Information Science*[9]. None of the authors whose single papers were referenced independently in [8] bears a direct link with the authors in ref. [9], nor the only case of cocitation, though some of them may be found among the *references* in the papers from [9].

This exercise in bibliometrics could be pursued in more detail, but it does show thus far that within a decade or two in the 60s and 70s the diversification of information science (concept) did not diminish. The interrelationship of intellectual frameworks is meager suggesting a transition state, or, if preferred—a preparadigmatic state.

The sources for this conclusion may be criticized on the ground that both the selection of invited speakers to a conference[8] and the papers selected for a reader[9] are subjective choices. A more objective pattern is expected to emerge from cocitation analysis. White and Griffith[10] thus discerned five main author groups within the field of information science for 1972–1979: scientific communication, bibliometrics, generalists, retrieval evaluation and precursors. From the authors' names I listed here, there is one in the first group, one in the second, three in the third, and none in the fourth and last group. The *map of information science* in ref. [10] is illustrative in its own right of the fluidity of the field, with perhaps other possible ways of group clustering.

In addition, the transition state has been illustrated quite recently both (a) internally for the various sciences and (b) externally, in particular with regard to information (meta) sciences[11,12,13].

The transition state, or the preparadigmatic one, for information science(s?) has vividly been exposed in two recent papers. In the first[14], Kochen dwells on the very meaning of the term *research* for information sciences. The rest of his article is a case in point, showing the shift in the thoughts of this author within a year or two. The second paper [15] illustrates, too, a drive to evolve adequate *designs of research* in information science. This may be likened to constructing appropriate scaffolding for drilling oil. Prospecting methods are needed first, however, in order to locate the proper drilling area.

2. SELF-(RE)ORGANIZATION/STRUCTURING

Accepting that the sciences in general are in a state of transition and particularly information science, one faces the question whether this is a normal state for information science or is a more orderly state of affairs likely.

Considering the second of the idea papers[16] for the present essay, one tends to opt for the latter possibility, without proving it is *the* choice. What is at our disposal is only an analogy, and, as usual, a seductive one.

Jan Robert Bloch presents[16] a unifying concept for science instruction based on (a) Prigogine's nonlinear thermodynamics far from equilibrium; (b) Haken's "synergetics", i.e. his theory of cooperative effects and phenomena in multi-component systems, and (c) Jantsch's concept of evolution as a universal key principle. References to (a), (b), (c) are reproduced here as [17–21] in the order of appearance in [16]. Eigen's hypercycle theory, providing an understanding of the origin of living matter by recognizing nonlinear,

autocatalytic systems as a *condition* for development, was also referred to in [16], but without a citation (here [22, 23, 24]).

To quote from [16]: "Prigogine recognizes *nonequilibrium* as a *source of order* and he employs the term *dissipative structures* for the concept of the *self-organization* of *matter* in *open systems* far from equilibrium. . . . Erich Jantsch has explored and developed the dynamic principle of self-organization from the *origins* of *living matter* to the sphere of *human reasoning*. . . ."

Bloch[16] distinguishes among the known examples of systems in the transition state those which an external energy flux is passing through and those (mostly biological interactions) which ". . . maintain their dissipative self-organization by themselves, i.e. by means of *autocatalytical* processes. . . . These systems meet the quality of *autopoiesis* (the Greek word for self-creation) and are characterized by a certain *autonomy* with regard to their environment, thus maintaining a self-reflective productivity in which the surrounding plays a minor role. . . ."

Though mainly aimed at a unifying (integrative) concept in (natural) science teaching (instruction) and hence with most of the real examples from the inanimate world, Bloch's paper[16] also blurs the boundaries between the "hard" and the "soft" sciences. Bloch insists on demonstrating the limitations of the all-degrading entropy concept: "Understanding the concept of development is a prerequisite for the constructive notion that our world is not one of irreversible corrosion (whatever we may be doing) but still demands our *knowledge* and *activity*. Thus, the frequently cited limits of growth attain embodiment in a larger framework that contemplates both the *limits and the evolution of structures*, finally leading to a 'growth of limits' by means of dynamic processes in nature and *history*. . . . The theory of self-organization and its explanatory function with respect to growing complexity of scientific fields, provides a bridge for openness towards problems in the social sciences. This scope implies the productive funeral of C.P. Snow's thesis of the two cultures (which has contributed much confusion in discussing science and the humanities), thus giving a new perspective for both nature and history. . . ."

While the theme of *the two cultures* will be brought up again in Section 3, let us point out that Bloch has thus ended his paper with far-reaching conclusions, almost with prophecies, by extending the "autopoiesis" to the sphere of human intellect, encompassing social phenomena, too.

To refocus, however, on information science—let us see what indeed is the analogy with the characteristics of a self-organizing situation as enumerated in [16].

Section 1 here provided, I believe, ample evidence that information science is *far from equilibrium*. This is analogous to having passed over the *instability threshold*[19]. The latter term, however, pertains to situations with external energy fluxes through the system. With the tremendous impact of technology, accompanied by vigorous social changes[13], the information field (and, hence, its science) may be regarded as being under an energy flux.

On the other hand information science does maintain a certain amount of *autonomy*, not as a defined whole but rather as centres of crystallisation of its partial structures within the spectrum of various established sciences.

On the whole, the information field and hence its science is a system exhibiting *openness* to a high degree, by virtue of its essence—intellectual communication within a vast array of communicating dipoles. However, because of the diverse crystallizing structures, the openness is under threat of isolationisms.

The latter counteract the cooperative phenomena characteristic of the transient states. For this cooperativeness to be effective in the present state of information science an interdisciplinary fertilization is required. Only in such a way will the *unstable motions* settle for those among them which are selected by mutual enhancement, synchronous at that, of course[19].

Hence, there is a chance, possibly a good one, for the *autocatalytic* process to take over, leading to *autopoiesis*[16] of information science.

Bloch ended his reflections with a demand for *our knowledge and activity*. Were the inanimate world in question, even the biological without reason, one would expect that autopoiesis would simply work its way. Dealing within the realm of reason as the culmi-

nation of biological evolution, and with the communicative role of information science in the very evolution of reason—we are merging, quite uncomfortably, the object, i.e. the development of information science, with the subject, i.e. the people acting in the information field/science. Were it not for this interrelationship we could dispense with many a generalist conference, also with many treatises like this one, and let history do its job.

In point of fact, whether the third section here should have been written (or be read!) at all depends on the extent to which the *subject* as defined here could be instrumental in the *autocatalytic* process of bringing about a coherent information science, in view of the cooling words of John Ziman[5]: ". . . we see science as a vast collective undertaking, where growth and change occur on a larger scale than any individual can hope to influence. Whatever we attempt to achieve by our own efforts, the 'moving finger' of progress will write, and move on, at its own rate, and we must harmonize our own lives and careers to it as best we can. . . ."

While these words oppose sticking to one's particular subspecialty for a long time, the underlying thought can be extended to information science itself: only within the broadest contexts or strategy can there be a hope to develop the identity of information science, because it is by its own virtue dependent on the changes in our civilization.

Whatever this basic strategy turns out to be, it will have to cope with the equally basic and inherent paradox: the autonomy of information science involves the danger of its compartmentalization within the parts of its surrounding—towards which it should behave autonomously in order to be "autopoietically" creative. In other words, there is the paradox of information science openness vs. autonomy, because of the tendency towards isolationism inherent to autonomy.

3. INTELLECTUAL (HUMAN/SOCIAL) COMMUNICATION

The concept of information (science)

The third of the idea papers, by David Rudd[25], deals with the importance of the content of information and the context of its development as opposed to the notion of *materialized information* (my term). I have reformulated the basic implication of Rudd's analysis in the Introduction (premise iii). In his own wording[25]: "If Popper's third World model is accepted, then information is seen to inhere in things (books, problems, theories, etc.) which people may or may not understand. This is an essentially passive conception of information—and one which produces an information science that relegates the production of information to very low priority (if it recognises it at all, and does not consider it an issue for other disciplines). On the other hand we have a much more dynamic concept of information which says it is meaningless to speak of information divorced from people (both creators and users). . . ." Paraphrasing Popper's distinctions of various *Worlds* Rudd has written the above passage, quite adequately, under the section subtitle *Socialworlds 2 and 3*.

It is hard to see any direct criticism relevant to this crucial point of Rudd's in the brief comment by Brookes[26]. Notwithstanding the philosophical side of the issue the social core of the concept of information (for information science) has been arrived at, in a completely independent discourse, by Belkin[7], whom Rudd[25] does not cite. Belkin[7] says: ". . . given that the scientific model of attaining knowledge is appropriate for information science, formulation of the problem which it wishes to solve is of basic significance . . . (and) I take that problem to be—facilitating the effective communication of desired information between human generator and human user . . . — . . . 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 . . .," and he duly acknowledges all the other authors with their approaches which helped him. Among those, I requote here Wersig and Neveling's premise accepted by Belkin and Robertson[27]: "Nowadays the problem of transmitting knowledge to those who need it is a social responsibility, and this social responsibility seems to be the real background of information science. . . ."

The information science "membrane(s)"

At first sight the paper by Robert Yager[28] is not within the realm of information science. Yager writes of recent (last five years) changes which indicate ". . . the centrality of the *science-society interface* for science education as a discipline. . . ."

It should be stressed that the author is not concerned with science teaching or instruction (the case we had in section 2 with ref. [16]), but rather: "Science education is defined, then, as the discipline concerned with the study of the interaction of science and society – i.e. the study of the impact of science upon society as well as the impact of society upon science. Their interdependence becomes a reality and the interlocking concept for the discipline. Research in science education centers upon this interface. . . ."

Yager likens the discipline, as a science-society interface,". . . to the *cell membrane* . . . separating the living material from its surroundings. The membrane is a *dynamic* one through which all materials must enter and exit the cell itself. Studying the process and the factors controlling such movement, the direct *involvement of the membrane in the actions* can be used as a parallel in terms of science education and its role in assisting society *to understand* and *to use* science while assisting professional scientists *to understand* and to *affect* society. . . ." Defining thus the discipline of science education Yager prophesizes that it will be *a vital link to the future of mankind*, a statement with which one can hardly disagree.

Now, at every step of this reasoning the concept of information (for information science) is inherent, though within only one possible *context*, that of *purposeful, meaningful* communication (see ref. [7], Table 1). I submit that, with the *social (human) substance* of the concept of information taken for granted, a number of membranes pertaining to specific contexts may be envisaged, and that, because of this model's ubiquity, information science may, too, be likened to a *dynamic membrane. It studies ways by which humankind's cognitive creativity, with perpetual change of its content, becomes humankind's everyday living force.*

As good and seductive as it may be, the last analogy cries for more concrete elaboration of the membrane pathways, or, in other words, what centres for crystallization of information science may be envisaged within such a conceptual framework?

Continuing with the membrane analogy let us bear in mind that the current picture of a biological membrane is not only that of separation of the cell while providing uni- or bi-directional communication channels. The membrane extends into the cell itself, providing for various kinds of compartmentalization with concomitant harmonization of the whole (cell) structure. The rest of this section is therefore organized in view of the size and spread of the fields(s) embraced by the information science membrane(s).

The internal membranes

First let us deal with the *internal* topics in information studies. Here, too, there is a paradox: on one hand any information mechanism or tool (technology is the beloved word) when properly studied may open new vistas in communicating information whatever the subject matter may happen to be; and yet, on the other hand, there is the danger that the obvious openness may turn into an undesirable isolation of information science, as it looks upon itself, or, rather, on its own tools. The danger may be like the one already experienced in (classical?) librarianship as pointed out by Thomas Shaughnessy[29], due to a preoccupation with various institutional contexts, which focuses attention on the form of the discipline rather than on its substance. However if the information science crystallizes in the context of its *social substance*[25,27,7], self-compartmentalization or involution will be less likely to occur. Here are a few internal lines of study by way of illustration.

Survival of computerized information. If any *energy flux* is thoroughly permeating the field of information (science) it is from the sweeping technological innovations. Neavill[13] for instance points to the cardinal changes in the very nature of Popper's third World, without, indeed, mentioning it at all. This *is* a subject of study for information science of most general interest. Though mostly inwardly orientated its implications are manyfold. Neavill says that proponents of computer-based electronic systems have left aside the issue of the long-term survival of information, while this is especially important if such

systems are to play a role in formal scholarly communication. Whether this line of study deteriorates by aiming just to save the "dead third World" or, on the other hand, to take into account its social and pluralistic realization is precisely the issue taken up by Rudd[25].

In his recent paper[30], Manfred Kochen reemphasizes the computer paradigm *within the information sciences.* While no one can (nor has to) deny the development in artificial intelligence, for instance, the question is could these studies have been taken up by information science autonomously? In asking this question it is good to recall a 10-year-old warning by Victor Rosenberg[31] that information science must abandon its deterministic approach and must recognize the computer as perhaps an historical accident rather than a scientific organizing principle.

Moreover, Kochen[30] appears to be impressed by the progress achieved in molecular biology studies of biological information. Here again, as with expert systems in artificial intelligence or computer achievements on the whole, the danger for the development of information science lies in the neglect of the human (social) aspects of creativity. The same author pointed to the latter, one year earlier, in his review paper[32] which inspired in many respects the writing of this essay.

Communication between (science) disciplines. Another internalistic field of inquiry by information science concerns communication between different sciences. I call this field of inquiry internalistic, because, as in the preceding case it is still confined to the realm of scientific endeavour itself, but this time it is confined to the interrelationship of various sciences. This *scientific* communication among various subject (super)specialities is important in two ways: (i) to enable cross-fertilization of (research) ideas, i.e. it is important for the general progress of science itself, and (ii) to enable *synthetic digests* applicable to the well-being of the society, or, rather of humankind.

There are frequent pleas for (i) as for instance in the whole of the book in which Ziman's contribution appeared[5]. Then, can information science devote part of its efforts to answering the question of whether one could expect at all any mechanism for this kind of communication other than that which, intuitively, appears to be the only possible one: the brightest scientists moving from one speciality to another?

The language of communication across speciality barriers is certainly a prerequisite for true interdisciplinary research, and yet cases of such a research are rare. Thus far it is not even easy to determine the amount of interdisciplinary research underway[33,34]. The impersonal style of scientific papers has been under scrutiny, too[35]. To what extent could a mere change in style help? While the terminology of the specialities is probably the more difficult aspect, the style is certainly in the forefront of the problem of fluent communication between the natural sciences on one hand and the social sciences and humanities on the other.

For these *two cultures*[36] to evolve a mutual sharing of ideas within the well-informed and well-educated segment of society, i.e. still within inward orientation of information science, studies of ways to present *distilled knowledge* from either side in a style appropriate for a generator's conceptual structure *modified* by purpose, intent, knowledge of the *recipient's state of knowledge*[7] is very much required. The internal membrane of information science is obvious here. But do the *two cultures* need and wish to diminish the gap that surely still exists?

The two cultures. This actually is yet another question for information science as an internal membrane. The subject of a society split by the "culture of the Mind" will be left for the next discourse along these lines, while an emerging controversy will be dealt with first.

A well documented case about the differences in scholarly communication between natural sciences (NS) and social sciences (SS) can be found in the papers by Michael Brittain[37,38], but also in a number of publications by other authors, the grading of the softness of various sciences being all too well known. However, it is far from clear whether there is indeed a rapprochement between NS and SS as far as the information science is concerned. Brittain[37] reinterpreted after nearly 10 years the results of two large-scale investigations into information practices in the social sciences: contrary to the earlier conclusion, he now finds that many of the results lead to conclusions very different from those

made at the time they were first published. In the other article[38] Brittain summarizes all the aspects of social science research which distinguish it from NS. Another author (Ralph Adam[39]) is of a similar opinion, though the two of them do not refer to each other's work.

It thus appears that this half of the culture has retained its autonomy with respect to the natural sciences, or *vice versa.*

On the other hand, there are two cases to bring as evidence in favour of closing the NS–SS gap as far as citation practices go: Marvin Leavy[40] concludes that the age of references hardly differs, but carefully states that one ". . . can not be sure that the recent convergence in age of periodical references between NS and SS fields' publications bespeaks a common orientation in how their practitioners select them . . .", but also that ". . . recourse to differing models of paradigmatic continuity is unwarranted . . ."; Small *et al.* [41] believe explicitly, based on current experiments with the 1983 SCI/SSCI files, that it is possible to include the social sciences in the same overall structure as the natural sciences and that significant links exist between these worlds of knowledge.

From here to ". . . the productive funeral of C.P. Snow's thesis of the two cultures . . ."[16] is a long way to go because even if the *pattern* of communicating information may be converging, cognitive communication between the two cultures remains to be dealt with by the inner membrane of information science, too.

In order to keep this essay within reasonable bounds I cannot expand on the theme of *The Two Cultures.* However, as it did not go unnoticed in *Perspectives in Information Science*[8] I have to advise the interested reader that the collection contains a few other papers worth consulting in this respect – one by Rosenberg[31] and the other by Jean Gideon Kesting[42], though both uncited in the Social Science Citation Index until 1984. Rosenberg[31] quotes a passage from Theodore Roszak's "Where the Wasteland Ends" in which the term *mindscape* is very appropriate here in dealing further with the *many culture problem.* On the other hand, rather than looking at it as a disarray of parts, it is more appealing to accept the (idealist's) stand expressed by Kesting[42] ". . . that a cogent case may be made for the conception of the sciences and the humanities, not as *two cultures* subsisting in barren isolation from each other, but as poles which derive their vital solidarity from the *continuum* of our total human culture. . . ."

I have not touched upon the humanties in this paper. One of the poles, apart from natural science proper, was the social sciences and we saw how complex its study is within the inner membrane information science. Let us then take that the *mindscape* varies in its appearance, but the differences are parts of the whole *mindscape.* Casting the eye now at the whole spectrum of the mindscape, we begin to deal with the external information science membrane, *viz.* the one supposed to be enabling *communication* between the cognitive part of the mindscape (originating mainly in Science) and the society at large – the people of abundant diversity with respect to individual or group mindscapes.

The external membrane

True enough, the information science does not deal solely with scientific information[7]. It did, however, emerge mainly from the information needs of scientists and has been developing to a large extent in this direction. In what follows the science–society interface will be kept in the forefront not because that is the only aspect of the *external* membrane of information science, but, as a vital link to the future of mankind [28], it *is* among the few cardinal problems of human civilization.

Concern is only with the best educated segment of the public from the two cultures when the term is being used at large. However, we should be concerned with the *third culture*, or that part of the mindscape represented by the most numerous society – the laypeople confronted with most of the questions which must be answered if this civilization is to come out of age and not simply vanish or, even worse just wither away.

While the problems of cross-disciplinary scientific communication are within the internal information science membrane, cross-mindscape *communication* is within the external membrane. James Halloran's paper with its telling title[43] is highly relevant here, because it projects information onto communication, and *vice versa:* ". . . the fields of experience,

the world of discourse of sender and receiver, must overlap before communication can take place. . . . It is important to consider the implications of communication being so often a matter of the few talking to the many . . . about the perceived needs or problems of the many, from the unquestioned standpoint of the few. We must ask if it need always be like this . . . as much attention should be given to the conversion and utilization of information as to its provision . . . only a small proportion of media news presentations (print and electronic) is understood or capable of being reproduced intelligently . . . due to the fact that the worlds of experience of encoder and decoder do not overlap to the required degree . . . (for) people to act collectively, with full knowledge of the implications of their actions. . . ."

Given that ideas providing cross-fertilization among the segments of scientific production bring forth fruits abundantly, how then can those messages encoded by the sender be expected to be decoded by the receiver who has to make up his/her mind about them (information?) in the course of social action? We have thus come to the problem of science literacy, and the term requires clarification.

Civic science literacy. A whole issue of *Daedalus* has been devoted to *Scientific Literacy*[44]. The paper by Jon Miller therein[45] deals with the evolution of the meaning of this term. However, *science* literacy must be distinguished from *scientific* literacy. This distinction is made here to indicate that science literacy is or should become a common mindscape, enabling anyone to develop an *attitude* appropriate to the complexity and rapid change of modern, i.e. future, society, in order to be capable of shaping it collectively. Not to be able to conduct any given piece of research because it is just plain impossible, but to be able to reason in a research manner, open-mindedly, inquisitively.

Kenneth Prewitt made[46] this fine distinction in the meaning of the term (and performed a good deal of fine analysis, at that) by suggesting the expression *savoy citizens*. Miller[45] also quotes Benjamin Shen who used the expression *civic* science literacy to depict *broader public* understanding of public policy issues.

If school system(s) appear to be producing civic science illiteracy[45], if the messages through the media are (therefore?) unintelligible, and in view of the too few vs. the too many malcommunications, the case is obvious for the outward operation of the information science membrane. The case for applying *information science* to this interface of the cognitive mindscape *and* the public at large is further strengthened by this passage in Brittain's paper[38]: ". . . the pressure for change is likely to come from outside the social sciences themselves and outside the library and *information profession*. The forces are likely to be economic and related to the distribution of relatively expensive and scarce resources. . . ."

Now, in studying the means of enhancing civic science literacy, not only through appropriate alteration of science teaching [16] and within the paradigm of science education[28], but primarily and concomitantly by information science, an inversion of the approach to science offered by West Churchman[47] may be of great value. "Opposed to the usual view of the research system is the notion that there is a universal need to discover—*not* that a researcher is a special kind of person, but that everyone is a special kind of researcher. If this is the case, then the basic question of the research system is no longer a question of which discipline should be supported but, rather, how we make research a more universally available activity for all individuals in our society. . . ."

If the scientists (including the social scientists) voice the idea that ". . . our major function or mission is not so much to give prescriptions, but . . . to broaden the range of *public discussion* . . .,"[48] then, unless polarized society is what our civilization can only have, civic science literacy is needed in order to have the *public proper* reach the consensus. The informational, communicational and educational aspects are inseparable in the study of the means that lead towards a more homogeneous mindscape. At present, the transition state in Science—to come back to the introductory section—is still characterized by the swinging of this public pendulum to and from the "egg-heads" and "omnipotent magician" imagery of the scientists, as succinctly summarized by Eisenstadt[48].

The four winds of the world. Eisenstadt also brings into the arena of reflections the

comparison of the Western and Eastern mindscapes. Adding to it the politico-economic North–South precipice would imply a global extension of the external information science membrane.

That there are quite concrete global problems to study has been indicated by Brittain's convincing finding[37] that the social science literature is mainly compartmentalized (parochialized) within national borders. That a global approach in information science is not out of reach is shown by Tefko Saracevic[49], for instance.

If the diligent reader has arrived at this point I am not going to quote others' thoughts anymore. However, I cannot resist the temptation to draw the reader's attention to a beautiful tiny piece of reflection—by Michael Hinden[50]—of much relevance to the point(s) I was trying to make in this essay. Do read it.

CONCLUSIONS

1. Being a function of changes in civilization induced mainly by growth in science, information science is presently in a transition state (i.e. far from equilibrium) and therefore prone to an autocatalytic self-(re)organization.
2. For the self-(re)organization to be effective, openness and autonomy of the system is required, which is fulfilled here by virtue of the intellectual communicative essence of the information, but there is a counteracting force of isolationism, or compartmentalization within many diverse segments of the human cognitive sphere.
3. The autocatalytic self-(re)organization of information science as a whole could be expected thus only within the broadest possible strategy implying the socially communicative core of the information concept: information science studies preponderantly the ways by which humankind's cognitive creativity with perpetual change of its content becomes humankind's everyday living force.
4. In likening the information science to a current view of the membrane structure of the living cell, two types of interfaces across which information science should take active part in the cognitive transfer processes are envisaged: (a) internal interfaces between various and divergent segments *within* the cognitive sphere itself, and (b) external interfaces *between* the cognitive sphere *and* the society at large.

Acknowledgements—It is a great pleasure to thank Professor T. Saracevic for his patience in reading the first handwritten version of this paper and for his subsequent advice and encouragement. Most of the referees' suggestions were valuable and the author hopes they will be satisfied with the final version. Last, but not least, my thanks to Mrs. Jessica L. Milstead for making my English much more intelligible than it was originally.

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