

# LARGE LIBRARIES

## AND NEW TECHNOLOGICAL DEVELOPMENTS

Proceedings of a Symposium held on the Occasion  
of the Inauguration of the New Building of the  
Royal Library, The Hague,  
29 September — 1 October 1982

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## Sixth Session

*chaired by W. R. H. KOOPS*

JOHN A. MICHON

### *How to Connect a Library with a Mind*

#### *Introduction*

Conventionally, information management has, to a large extent, been the work of librarians. Unfortunately, the recent developments in information technology have put the librarian in a somewhat uncertain position.

Until quite recently it was expected that hardware problems, such as computer memory size, would constitute the bottleneck in our attempts to deal with the avalanche of information that threatens to bury us. It turns out, however, that information *management* is in fact a much more critical issue. In addition it is now understood that information management is primarily a user-related problem. This reorientation requires a considerable change in the outlook and skills of librarians. Therefore, rather than discussing the *libraries* of the future, I prefer to concentrate on the *librarians* of the future instead.

One suitable question for highlighting the requirements which the new librarians will have to meet is: “how to connect a library with a mind”. Librarians will have to consider this problem in close harmony with cognitive scientists and specialists in the various branches of science and the humanities. Librarians of the future must be able to understand the needs of various categories of users and at the same time they will have to be capable managers. There are several ways in which we can outline the characteristics of a new type of professional information scientist. It is not likely that library science will survive in its present form: the librarians of the future will have to broaden their scopes and skills. They must be able to cope with the technology, the organization, the management and the marketing of information — or rather *knowledge* — at the same time. Some will stay in libraries, classifying and shelving documents. Many more, however, will become colonists, claiming new territory in the world of symbols.

### *Uneasy Feelings*

Throughout the year 1982 auspices have been good for Dutch Library and Information Science. First, the Dutch people were strengthened in their stubborn beliefs that, against all historical evidence, it was after all Laurens Jansz. Coster of Haarlem who invented the art of book printing, rather than Johannes Gutenberg of Mainz.<sup>1</sup> Secondly, the Royal Library finally could move to its new quarters, an event which is crucial for our being together today. In the third place, the Minister of Education and Science did establish the Advisory Committee for Research on Information Transfer which, I understand, is the reason for my addressing you here. (Whether the latter point, in itself, does indeed spell any good remains to be seen, of course).

All these happy events suggest that we may be at the brink of a period of both serene contemplation and vigorous action, generously supported by the government, which will enable Dutch society to negotiate the rapids and cataracts in the stream of information to which we are heading.

With all these good auspices then, why do we notice so many uneasy feelings and why do so many augurs foretell doom for the library as we know it today? Why is there “reason for very serious concern for the survival of libraries”?<sup>2</sup> Several reasons may be mentioned, some of which have to do with the cost-effectiveness of libraries, others with difficulties in deciding which of the recent technological developments to embrace. Still other reasons derive from fears of unemployment as a result of automatization. I think, however, that there is a more basic reason lying at the root of all the others: there is a deep feeling of uncertainty about the foundations on which the profession of the librarian is based. This uncertainty has been paraphrased by several authors. Shera and Cleveland<sup>3</sup>, for instance, argue that “if information science is to be accepted as an academic discipline, then it must find a strong theoretical foundation and, clearly, such a foundation must be structured around some consistent notions of information”. In a similar context Emery<sup>4</sup> stressed that “we have an urgent need to develop solid theoretical underpinnings of information systems”.

Lacking such theoretical underpinnings the general attitude of insecurity becomes understandable. The question then is whether we can alleviate those feelings or, in other words, whether we can formulate a theoretical framework that will be able to support the further development of library and information science.

In this paper I wish to propose a suitable candidate for such a theoretical framework. First, however, we shall need to consider the conditions which have led to the present situation.

### *The Library of Babel*

Laurens Jansz. Coster's invention has had tremendous impact: it seems as if mankind has grabbed with both hands the opportunity of printing all and any permutations of the 26—and some—symbols. “Information generates information”<sup>5</sup> but as a result we may have wound up in a positive feedback loop: to be able to cope with the requirements of the information environment, we need more information, which in turn requires

even more information to deal with the information that is already there, and so on until the system explodes.<sup>6</sup> There is unfortunately not much theory to guide the intelligent development of strategies for organizing and controlling large quantities of information. Newell, for instance, recently characterized the state of affairs in one of the most pertinent research fields, Artificial Intelligence, in terms of an “overwhelming diversity—a veritable jungle of opinions.”<sup>7</sup>

One serious consequence of this unhappy situation is that it remains entirely unclear in what sort of equipment and methodology libraries should invest. Given the cost of adopting a particular system, those who choose now may well find themselves hooked up to the wrong system for the next twenty years. If things were as they should be, however, a theory of information transfer would provide the guiding principles: one would at least have a clear idea about *what* to do before having to decide on *how* to do it. Now it is almost as if we are re-creating the Library of Babel as it was envisioned by Jorge Luis Borges.<sup>8</sup> In his story Borges paints a huge library, very much like an enormous beehive. The Library of Babel consists of hexagonal cells with five shelves on each of four sides, every shelf holding 35 books of 410 pages each, 40 lines to the page. The librarians in this library entertain a theory: all permutations of the 26 symbols are there. There are no two identical books, although some differ only by one letter or comma. Of course most of the volumes are formless and chaotic. Others, however, are more systematic: one of the books, we are told, “in a hexagon on circuit fifteen ninety-four was made up of the letters MVC, perversely repeated from the first line to the last”. The story relates the vain attempts of the librarians to impose a structure on this non-system of documents. Not surprisingly it is a story of suicide and murder, of intrigue and inquisition. It is a story of hope: “on some shelf in some hexagon... there must exist a book which is the formula and perfect compendium of all the rest”. And it is a story of despair: the moral and cultural decay sets in when the librarians realize that every possible book has already been written.

Pessimists may be tempted to recognize this description as the gloomy situation that sometimes appears to be closing in on us: an avalanche of ever more information in which it becomes increasingly difficult to distinguish between the valuable and the trash. What should be kept and stored, and how can we possibly make and keep such a body of symbol patterns (I deliberately use this abstract term) accessible? That is the question, and it seems we'd better come up with an answer pretty quick!

#### *Libraries of the Future, AD 1964*

It is important to *see* what happened in the past twenty years. Expectations and actions of that optimistic and slightly naïve epoch certainly helped to shape the situation that is prevailing now.

An important source for this is Licklider's well-known monograph, *Libraries of the Future*.<sup>9</sup> This book offers a view of hardware and software developments as they were expected in 1964, and as they were thought to influence future library and information services. An evaluation of Licklider's views seems rather appropriate today:

1982 is exactly halfway between 1964 and 2000, the year in which, we are told, the future will *really* begin.

Apart from a number of very well chosen and useful issues, the book contains two major points that deserve a critical examination. The first is the author's perception, at that time, of the rates of development in hardware and software systems respectively. Like many others, Licklider has proved overcautious with respect to the sizes and speeds of computers, while at the same time severely underrating the tremendous difficulties that would confront such issues as intelligent programming and network organization. The drop in cost of storage and the increase in speed of processing have exceeded all expectations. At present between 80 and 85 percent of the cost of a computer is related to programming, and less than 20 percent are actual hardware costs. Consequently the amounts of information to be stored are not going to be the bottleneck in information management as was thought in 1964. Instead programming, in particular knowledge representation in data networks and natural language understanding, have not progressed nearly as fast as was expected at that time. This leads us to a rather disquieting conclusion: since programming and intelligent data management have not kept up with hardware technology we can hardly manage the increasing amount of information and, more serious for libraries, it indeed remains unclear in which equipment and methodology they should invest.

This brings me to my second point of criticism: in Licklider's future libraries there is no place for real people! The user remains a ghost at the teletype and a ghost with a very abstract and scientific mind at that! The real librarian on the other hand is hidden behind silver and gold buttons on the terminal console and is actually a mere ghost in the machine. Yet, if in the past 18 years we have learned one thing, it is that the successful implementation of *whatever* man-machine system of *whatever* technological complexity hinges upon its acceptance by both the user and the systems managers. The song is quite old, and I am able to sing it to several melodies. Let me give you an example. In the early sixties the introduction of a highly sophisticated semi-automatic flight control system at Schiphol almost fizzled out, simply because the air traffic controllers who had to use it had not been involved in its development, nor consulted about the new system. Only when we were able to alleviate their fears of unemployment and loss of job status in combination with some genuine improvements in the system, the controllers were willing to accept the new procedures.<sup>10</sup> Such 'irrational' (?) motives tend to be more prominent than technical shortcomings of a system, although technical deficits usually can be traced more easily and thus may hide the true background for the display of ill feelings.

*Libraries of the Future*, for all its merits, has missed these two crucial points. It was practically blind to the user and acceptance aspects of the information revolution. Now, halfway between 1964 and the magical year 2000, we can see much more clearly that we are running the risk of becoming like the Sorcerer's Apprentice: unless we learn more powerful and adequate magic spells we will drown while the chips from our broomsticks will go on indefinitely, pouring information into our overflowing libraries.

### *The User of the Future*

Although it has been argued by many authors that the *user* will be the crucial factor in the libraries of the future, and although a large number of user studies seem to have been carried out <sup>11</sup>, we still do not know a great deal about what users need and want. Even less do we know what users of the future will need and want. Yet we should make up our minds — and perhaps theirs as well. There is not much time left for hesitation; we would soon be seriously out of phase with a number of imminent social developments. Most important among these is, in my opinion, the fast developing trend towards exposing children to the computer at an early age. *Time* magazine signalled this trend already several years ago. In a recent view *Time* described a new variety of Homo sapiens which it called the Microkids.

They are part of a revolutionary vanguard: the computer generation. Not only is this generation propelling traditional education down promising avenues, it is tugging at the entire social fabric, foreshadowing changes at least as startling and momentous as those ushered by a new generation of automobile users more than half a century ago.<sup>12</sup>

Said one initiate: “If you were born before 1965, boy, you're going to be out of it”, and another: “When I grow up it's going to be the Computer Age. It won't affect parents. They're out of the Computer Age. They had their own age”.<sup>12</sup> Even if this expulsion from the computer paradise would become reality, the fact which clearly emerges from *Time's* analysis is that it is the parents who exert considerable pressure on the schools for good computer classes already in the low grades! Susan Crooks, in her scenarios for the *Libraries in the Year 2000* <sup>13</sup>, expects the same bottom-up pressure. From the imaginary year-2000 stance that she adopts she sees that “in what might otherwise have been a slow moving situation, local pride and family pride drove consumers to demand that education catch up with homes, offices and factories”.

This should warn us; even though it is expected that probably not much more than about one-fifth of all the children will become actively interested in mastering the computer, such a proportion is more than is needed for a successful revolution, or for a social movement to become thoroughly entrenched in society. It should warn us against thinking that we do wise to “sell the old systems better instead of engaging in the development of new systems”.<sup>14</sup>

It should also warn us not to give too much weight to factors which reflect our current preferences for documentation and information. Illustrative of that attitude is the expectation that authors' pride may effectively delay a ready acceptance of electronic (scientific) journals: scientists would presumably derive too much satisfaction from seeing their ideas and results printed. Arguments such as this fail to convince, because they are conceived by people who early in their own careers have obviously learned to take a pride in seeing their names printed on paper. We know, of course, from actors, musicians, movie directors and politicians, that there are many other ways to see one's vanities tickled. What is and what is not considered gratifying is largely determined by fashion, generation gaps, and novelty, rather than by intrinsic value. A sound relativistic stance in this respect is adopted, for instance, by

Crooks in the study just mentioned, when she predicts that by the end of the 1980s people will have unconditionally accepted working with visual display units. Their preference for permanent copies of documents will become restricted to situations where permanence has indeed functional significance. The same will happen with other, as yet perhaps eerie, aspects of information systems. The conclusion is that we should look to the future, not with our own eyes but with the eyes of the next generation as well, a generation which will certainly show several of the characteristics of the microkids portrayed by *Time* magazine. In fact we should try to deal with users of all generations, which, of course, throws us back on the earlier conclusion that we need a thorough theoretical underpinning for information science.

Recent analyses fortunately deal with the user more explicitly. Crooks, in fact, presents a set of plausible scenarios, based on the premise that

... there is a reason for very serious concern for the survival of libraries, but there is also reason for believing that vital roles for libraries will continue... Libraries provide a setting in which people add or exchange their ideas (and learn and find entertainment) and in which people share the experience of working with ideas.<sup>15</sup>

This, in my opinion, provides a more appropriate perspective, namely what is it that any conceivable user or category of users could wish to know? What seems the valuable aspect of Crooks' approach is that she bases her scenarios on particular types of usage. We see here — and I will come back to this point later — that libraries should not centre around the concept of book (or document or symbol string) but around the characteristics of the information as they are dictated by the needs of the user.

If we take all these problems into account, we might come to the sad conclusion that librarians have been put on the wrong foot by the Great Expectations of, let us say, 1964. They realize they have to cope with practically unlimited supplies of information which is difficult to manage; they themselves believe they have too narrow a view of the needs of the various kinds of user; and — worst of all — they believe they stand on theoretical quicksand. It is appropriate, I think, to ask what can be done about this gloomy, “near apocalyptic” prospect.<sup>16</sup> Let us therefore look at the Librarians of the Future rather than the Libraries of the Future. If the librarians are sound, the libraries will take care of themselves — if you allow this hyperbole!

### *Librarians of the Future*

At this point it is relevant to introduce some concepts which we owe to Nobel Laureate Herbert A. Simon. His book, *The Sciences of the Artificial*, first published in 1969, has had a great impact on the ways psychologists are now thinking about their own profession.<sup>17</sup> And since there are several non-trivial analogies between psychology on the one hand and information and library science on the other, the latter can learn a great deal from Simon's position.

Let me be more specific. Psychology is, according to Simon, like the technical sciences in that it is concerned with the *interfacing* between a system and its environ-



ment. This concern requires knowledge about the structure and functions of the system as well as about the properties of the environment. However, since the human being is an extremely generalized, flexible and adaptive information processing system, we will, under normal circumstances, learn more about people when we study their environment than if we try to sum up their internal workings. In the same way, observing a ladybug crawling in my garden will teach me more about the irregular surface of my flower beds than about the inner workings of the insect. As far as human behaviour goes there appear to be only a few behaviour-limiting constants. One of them is the capacity of human working memory, that is the memory which we use, for instance, to keep a telephone number in mind while we walk from the directory to the phone. These limitations will, however, become prominent and detrimental if the organism does no longer properly 'fit' its environment, something which is all too often the case in the highly artificial environments man has created for himself. Psychology—and more specifically ergonomics—is especially concerned with the mutual adaptation (interfacing) between people and their environment by organizing the environment in such a way that (a) the limitations of the organism are not, or at least not often, transgressed, (b) the potential is properly used (through training), and (c) job aids (such as typewriters, vehicle controls and computer languages) are optimally adapted to the user. Society's present concern for the 'user-friendliness' of all sorts of equipment and organizations appears, now that I think of it, to be the ultimate victory of the ergonomic point of view!

This stance is in a non-trivial manner also relevant for the domain of cognitive activity that is the concern of the field of information and communication science. Interfacing the human being with the symbolic environment—with Popper's Third World, if you like—is a 'science of the artificial' in a double sense. What was said about the problems of interfacing between people and their task environments is equally valid when it comes to the interfaces and job aids that are characteristic for the cognitive domain. These interfaces are the knowledge representations (such as sciences, ideologies and philosophies) that people build for themselves in order to cope with the world outside, while libraries (together with scratch pads and knotted handkerchiefs) are among the most frequently used cognitive job aids. I propose that the librarians of the future will become the experts on interfacing and job aids for connecting people with the world of knowledge.

#### *How to Connect a Library to a Mind*

If we adopt this frame of reference as a proper one, we may consider the various problems confronting librarians as specifications of a more general question: how to connect a library with a mind (or a brain: I am not inviting a mentalism-materialism discussion!).

In answering this question I wish to draw a somewhat plausible portrait of the librarian of the future. It seems appropriate, however, to present a somewhat picturesque first sketch. The exaggerating brush of science fiction seems particularly suited for such an attempt, if only because the exchange of information between intelligences is one of the persistent themes of this literary genre.

### *Direct Transfer: Implantation Techniques*

The problem we have to deal with is the transfer of information or knowledge from a data source to a human mind. The most direct way would seem to be influencing the structure and the functioning of the brain by implanting, for instance, brain tissue from someone else. A striking example of this approach, which would turn the librarian of the future into a skilled brain surgeon, can be found in a short story by the Dutch author Belcampo.<sup>18</sup> In this story, which is set in the early years of the twenty-first century, brain surgery has reached a level at which very specific memory circuits can be electrically eliminated or rewired. Among other useful applications there is one which allows army recruits to go to a brain clinic and to have all the relevant knowledge and attitudes of an expert soldier implanted in less than half an hour. Implantation, excision and the trading of memories have become big business: in Amsterdam we find the Royal Recollection Exchange, and even in small provincial towns one can consult memory brokers.

This story has its variations, some of which have already come true. Implantation of electrodes can suppress epileptic fits, stimulate one's pleasure centre — whatever that may be — or even make a starved dog turn away from its food bowl. There are even semi-serious attempts to implant electrodes that are connected to a bank of photo-cells as a visual aid for the blind.

However, I think you may sit back and relax: for the transfer of knowledge this kind of future will never come true. It may be that for each possible mental state a corresponding physical state of the brain can indeed be found. This conjecture is philosophically known as 'physical state identity theory'. What is not the case, however, is that one could possibly specify which mental state does in fact correspond with which brain state. In other words, an infinite number of different brain states may produce one and the same mental state and vice versa. This functional equivalence of brain states lies at the very heart of such ancient questions as: how do I know that what I see as green is not seen by you as what I would call red? This so-called privacy of experience is fundamentally the reason why the librarians of the future will not be educated in medical school.

### *Symbol Codes*

Let us, therefore, turn to the next, perhaps more realistic, prospect: the librarian as communications engineer. In this case the scene is set by Fred Hoyle's marvellous novel, *The Black Cloud*.<sup>19</sup> The title hero (or heroine?) of this story is an extraterrestrial intelligence who is embodied in a cloud of organic interstellar dust. The cloud contacts Earth when she briefly visits the Sun for fuelling. The Black Cloud turns out to have an insatiable thirst for knowledge. She absorbs all available documented knowledge broadcast to her in a matter of a few weeks, only restricted by the transmission rates of the terrestrial radio systems. Surprisingly the Cloud is of an essentially benevolent type, and she agrees to share her own wisdom with Humanity. She does so by transmitting a highly abstract visual code via a bank of visual display

units into a human mind. This creates disaster! The volunteer subject dies in a fit of brain fever before the transmission is even completed. A second subject survives only slightly longer, even though the transmission rate has been slowed down considerably. It is only after the Black Cloud has left that those in charge of the experiment realize that they have used the wrong volunteers, namely two highly competent scientists with extremely well developed knowledge systems. The tragic outcome of the experiment is a consequence of the utter incompatibility of the ways human beings and the Cloud have their knowledge internally represented. Too late it is recognized that the guinea pig should have been “someone of a far slighter intellectual calibre [because] if it was contradictions between the old knowledge and the new that destroyed [the first two subjects], then surely someone with very little old knowledge would have done better”. Of course this phenomenon is known in less dramatic forms too: think of the many years it took physicists to accept the idea that light is particulate and wavelike at the same time!

Hoyle's story teaches us that it is not primarily the code—the rate and complexity of a sequence of symbols—which is the bottleneck in information transfer. Librarians of the future, like those of the present will indeed not have to know a great deal about signals and codes. Just like the electrochemical impulses in the brain at the physical level, the abstract impulses at the symbol level are only carriers of still higher levels in the descriptive hierarchy of the knowledge environment. In short, the physical implementation of information is ultimately something we may consider irrelevant—in this context I am hard pressed not to say immaterial! One exemplary implication of this lesson is that librarians should stop worrying about books as we know them today. Whether they will is, of course, something else!

### *Representations*

The most important thing that humanity did learn from its information exchange with the Black Cloud was the following: neither the speed nor the complexity of a code which interfaces the environment with a particular mind is the limiting factor. The problem is located in the nature of internal representations.

In the early days of applying information-theoretical concepts to human performance, many studies were carried out to establish a reliable estimate of the processing capacity of subjects in many different tasks, ranging from professional athletes and musicians to air traffic controllers and telex operators. The upshot of this research was that human processing capacity is indeed extremely limited and therefore incoming sensory information must undergo considerable condensation and reduction. Yet, once the appropriate knowledge structures have been established there appear to be hardly any restrictions on the capacity of coding and storing information. Even dealing with simultaneous sources of information does not create interference, as long as no conflict between two simultaneous representations occurs. Thus, as we all know, driving on a winding road and talking about quite serious matters is most often a very simple matter. On the other hand, solving a mental arithmetic problem such as ‘ $13 \times 41 = ?$ ’ excludes thinking simultaneously of such questions as ‘in what

year did Mozart die?'. Even if you happen to be the author of a leading Mozart biography, the use of two different representations of numerical symbols prevents the effortless simultaneous processing of the sum and the historical fact.

It will have transpired by now that, in my opinion, the librarian of the future will primarily have to cope with the problem of *representation*. In brief: interfacing a knowledge domain or a Popperesque 'Third World' with a human mind essentially amounts ultimately to an analysis and an understanding of the internal representation, the 'mental model', of the individual user. In this case, however, individual differences are not pernicious in the same way they are in the physical state identity theory mentioned earlier. It is only the knowledge representation as such which is to be 'fitted', not the electrical or the symbolic code which carries that representation.

This brings me to my third scenario for connecting a library with a mind. This time I don't think the story has yet been told in the form I envisage. It goes as follows:

In the early years of the twenty-first century you will get your first knowledge interface chip (KIC) at the age of three. (Some parents already give their children KICs at least a year before that, but most pedagogues and medical doctors do not recommend this, because its early use seems to interfere with normal development: stuttering, bed-wetting and the recent increase in teenage violence have been attributed to the KIC). A beginner's MC is simply a natural language chip which has been wired so as to be compatible with knowledge banks of levels 1 and 2. Since 1997 these two data banks — the so called 'concrete knowledge levels' — have a fixed internal structure. Level One contains permanent materials like, for instance, *Winnie-the-Pooh* and *Alice in Wonderland*, as well as semi-permanent encyclopaedic information. Level Two, on the other hand, permits interactive use of the major part of the stored data. Thus, for instance, children can deposit in it their interactively produced homework, which is then corrected interactively with the teaching programmes in this Level Two bank. At a later age you get other chips which give you access to more complex data banks, until when you are 16 your KICs have reached universal Knowledge-Bank Compatibility, including the X-rated Adult Only department.

The KIC is the result of the major breakthrough in procedural semantics which occurred in 1992, which made it possible for an intelligent chip to start with no factual knowledge but with some primitive questioning strategies on the one hand, and a detailed programme for optimal searching through the standardized data banks just mentioned on the other. The use of the KIC is actually very easy: every home, and every public building, has one or more terminals. One simply inserts one's KIC which is the size of a credit card. The KIC is absolutely privatized and made of circuitry that cannot be tampered with. Upon insertion, one can communicate with a data bank in a cumulative way. The reason is that, while information is retrieved from the bank, the use to which it is being put alters the information flow inside the chip: its programme is 'self-organizing' in such a way that it is always completely compatible with the changes in the internal representations of the owner. In the early days of KIC-technology, the scientists attempted to create one general chip to serve for all purposes. However, when Crombag, the famous Dutch psychologist,

formulated his cognitive specificity theorem in 1987, such attempts were immediately recognized as futile and subsequently abandoned.<sup>20</sup>

Knowledge about knowledge may be represented in many and frequently incompatible ways. This insight led to the idea that people would need several KICs, each of which would carry a different style of communication with its owner, such as to optimize the growth of the supporting KIC-network. This is why several levels of complexity have been specified for the data banks, and why most people will carry their KICS in a wallet, much the way they did with all their credit cards before the Mondipay Universal credit card was issued in 1998. This development, which was completed just before the turn of the century, did in fact pick up the early ideas about 'procognitive systems'<sup>21</sup> of a famous information scientist of those days, Licklider, and expanded them with the achievements on 'interactive expert systems', which began to be used in the late 1970s.<sup>22</sup>

### *The librarian as a cognitive scientist*

So much for science fiction! I hope you have picked up the gist of my argument from these rather fancy ideas: neither the neural level, nor the level of symbolic codes are adequate for telling you how to connect your mind with the world of knowledge. Neither the physical carrier nor the chosen code happens to be very interesting by itself. It is, in principle, irrelevant whether messages are transferred in written, or spoken form or by telepathy, just as it is (in very large measure) also irrelevant if the message is conveyed in Dutch, English, Japanese or Martian. Yet it *is* natural language that we have to rely on, since language is much more than a (syntactic) code. It is the universal way of connecting knowledge systems. This is because language — any natural language — allows speakers to pack their internal representations into a code which contains precisely those universal cues — the mental buttons and hooks as it were — that allow receivers of a message to decode that information into their own private knowledge representations. Evolution has sharply tuned our external languages and our internal representations.

This underscores the fundamental importance of being able to communicate in natural language with artificial knowledge systems such as computers. This has been understood, among others, by the Japanese Government, who have recently summoned a rather formidable task force of some 300 scientists.<sup>23</sup> Their task is to develop what is called the 'fifth generation computer' before 1990, a machine not unlike our knowledge interfacing chip. This fifth generation computer will be the first that is capable of communicating with humans in natural language, while at the same time it will have access to highly formalized, large databases, which allow it not only to babble but to communicate. This is a tremendous undertaking, certainly no less difficult than putting a man on the moon (perhaps even more difficult). Its expected social consequences, however, will be vastly greater. Since the Japanese are very serious about this project, the rest of the world has become very concerned too. As a result, our knowledge interfacing chip may be nearer than we now tend to believe.

If a science of information transfer is to achieve and retain scientific and professional respectability, it should consider knowledge representation the fundamental unit in its universe of discourse. Adoption of this suggestion would turn library and information science into a highly respectable branch of cognitive science, and the librarian of the future into a highly respected cognitive scientist. And that, I think, is the way it should be.

Knowledge or, if you like, that which constitutes the meaning of patterned information, has been recognized as an appropriate and independent level for the formal description of symbolic systems. Yet, knowledge in and by itself is of little use: a pattern of information can only count as knowledge if the pattern can be recognized by the organism, that is, if it can be *interpreted* as having a meaning or as fitting a representation. Listen, for instance, to someone speaking an unknown language, or look at a text in Linear-A-Minoan script: you can hear, or see, that here must be something to it but you can't tell *what* it is. You lack an adequate representation, because you lack the appropriate *access structure*.<sup>24</sup> The briefest possible summary of this point of view was recently formulated by Newell<sup>25</sup>, who presented the following compact functional equation:

$$\text{REPRESENTATION} = \text{KNOWLEDGE} + \text{ACCESS.}$$

Perhaps you will agree with me to the following analogy. Libraries are bodies of uninterpreted knowledge, the (physical) embodiments of the objects in a Popperesque 'Third World'. Only if there is an access structure—such as is normally described in an instruction manual, a grammar or a book of recipes—can that knowledge be given a meaning. This is what we call a representation. In the present context the user is the embodiment or carrier of representations. Whether or not a user is a physical object is, again, immaterial: angels, devils and even multinationals qualify too, in so far as they hold and manipulate representations.

In my opinion the librarian, and more generally the information scientist, should not be satisfied with the role of their colleagues in the Library of Babel: that of the custodians of the huge body of uninterpreted knowledge contained in libraries and data banks. They should instead assume the role of experts on access structures. On the basis of a deep understanding of representations in general and of the formal properties of knowledge as such, they should be able to design, build, and manage access structures, that is, procedures and equipment for interpreting knowledge such that a 'graceful interaction' between the cognitive environment and the user's cognitive processes is made possible. In short they should become cognitive scientists.

Well, that's it. Here is your theoretical underpinning, here is your management principle, and here is your user-oriented approach, all in one! Of course, you will recognize much, perhaps too much, of what I have said as part and parcel of what the librarian already saw fit to do for many a century. But that is beside the point. Professions are born, they grow, flourish, and then become extinct unless they succeed in renewing themselves. This time the question seems to be whether the librarian will find an ecological niche, a habitat that is part of, and consistent with, the developments in cognitive science as it is now being established.

### *Some Implications*

Before I conclude I wish to point out some practical implications of what I have proposed to you. What is the heuristic value of this perspective when it comes to real problems? Does it provide a firm stand? I think it does, as the following rather arbitrary selection may illustrate.

In the first place I think the cognitive scientist's view can provide adequate support for information system specifications, and for the evaluation of the performance of such systems. This would be an important advantage, since it would shift the emphasis from *technical* requirements to *psychological*, user-centred, requirements in a rather natural way.

Secondly, and equally importantly, the proposed view allows a close consideration of the availability of information (knowledge) and information services to everyone. Only relatively few people—scientists and professionals mostly—will be prepared to acquire the necessary skills for accessing and searching libraries and data banks themselves. Only when the knowledge interfacing chip becomes widely available will this problem be solved. In the meantime librarians will have to act as guardians of informational democracy: they should provide access structures not only for the holders of well-established scientific representations, but also for the fuzzy, incoherent representations that are held by most people on most topics (and by everybody on at least some topics such as the economic problems of the Common Market or the weather). This point is actually of tremendous importance. The new technologies create the hazard of a new type of illiteracy, which we should not allow to surprise us. Information scientists and educationalists are aware of this threat, but in my opinion no feasible short term solutions have been offered thus far. For instance, I doubt the relevance of the proposal to make propositional logic a required subject in the schools. Similarly a rather popular proposal—already mentioned—to concentrate on better acceptance of the old systems rather than on the development of *avant garde* systems, strikes me as careless, if not unrealistic.

A related issue is the possibility that the differences between the developed countries and the 'Third World'—not in Popper's sense this time!—will become even more pronounced than they already are as a result of the new information technologies. What is the good of international data banks if you have no access to them, or if you cannot access them in a way that is relevant for the local circumstances. Apart from financial and manpower problems this is very much a matter of understanding local knowledge representations. The latter problem is strictly analogous to that of many technological aid programmes. They frequently fail because the equipment and the job structures that come with these programmes are incompatible with the local beliefs and attitudes. Cognitive interfacing in such situations would be an extremely rewarding experience for information scientists. One can easily think of other equally relevant tasks in these and other related fields, including issues of shielding users against unwanted monopolistic tendencies of large computer manufacturers and of large data networks, as well as against the—equally pernicious—ideological and bureaucratic tendencies of modern governments who can barely suppress their desires to

monopolize, thereby frustrating the free exchange and free trade of information. The recent discussions around cable television, for instance, both in the Netherlands and elsewhere do not help to induce optimism in an impartial spectator.

The potential roles of the librarian of the future in this *mêlée* of social and technological issues cannot be caught under one heading. But at least one role seems to stand out as more innovative than any other. Because of its contrast with what has been the trend thus far—centralization of collections, and every librarian becoming a civil servant or a rank and file employee somewhere in the hierarchy of corporate firms—I expect a bright future for those librarians who will be attracted to become entrepreneurs. More specifically, I believe that those who predict that in a not too distant future the majority of all graduates from library and documentation schools will eventually be engaged in information brokerage, are close to the truth.<sup>26</sup> Rather than living a sedentary life, picking up the local crops from what is already cultivated territory, the new librarian will resemble the discoverers and the colonists: cultivating promising, rich and fertile little (or not so little) territories in the vast world of symbols and making manageable, accessible knowledge of them. Preparing for such a role should be facilitated by the professional curriculum of the would-be librarian of the future. Two unusual conditions will have to be fulfilled in that case, unusual because they run counter to tradition and to the separatist inclinations of university departments and faculties as we know them in this country.

The first is that schools and university departments that offer such curricula should create and maintain serious research programmes. Information science is on its way to becoming an experimental science, partly because future investments in information services will be very costly so that options must be compared and evaluated in advance in small scale experiments. This applies to software developments at least as much as to hardware developments. User acceptance is a tricky affair, intrinsically related to the ways people feel and think or, in other words, to the ways they represent their world.

Secondly, the theoretical basis I have proposed in this paper has consequences for the content of the curriculum too. Information science appears to require a combination of methods that classically belong to the repertoire of the humanities (in particular linguistics), the behavioural sciences (in particular psychology) and the social sciences (in particular management sciences). In the Netherlands we now *see* a tendency for these fields to embark on curricula that are tentatively called ‘alpha informatics’ or ‘social and behavioural informatics’. I deeply deplore this segregation. I think that we should not let this happen, and that, instead, we should join these bits and pieces into one solid information science programme that can indeed serve as a genuine pendant for computer science. Such a programme should also offer the professional background of the librarian of the future.



## *Conclusions*

There are, no doubt, formidable changes ahead. The most formidable of all is perhaps the unlimited availability of information that is promised by the new information and telecommunication technologies. If we do not wish ourselves in the situation of the Librarians of Babel we shall have to concentrate on the accessibility of knowledge, rather than on the management and availability of symbols. In particular the librarians of the future must find ways which will enable users to pick those elements from an essentially unlimited flux of information that will provide them with stable representations. The theory of knowledge as it is emerging in cognitive science should provide an adequate theoretical framework for a new professional image. The only way of connecting a library with a mind is to provide inputs so structured that they are maximally compatible with representations already held by the user. The future will see self-organizing interfaces which translate the standardized structures at the knowledge level into personal (and corporate) representations. Perhaps the Knowledge Interfacing Chip which I introduced to you as a prospect for such an interface is little more than a transfiguration of the Librarian of the (near) future, whose task may, to a large extent, be characterized as knowledge brokerage.

What I have offered you for consideration and discussion may seem strange in places and beyond reach in others. I thoroughly agree on the latter aspect, but not on the first: you should have lively feelings of déjà-vu by now! And why is that?

Last year we commemorated the second centennial of Immanuel Kant's *Critique of Pure Reason*.<sup>27</sup> Although not many of us know this work very intimately, its impact on the humanities as well as on science has been tremendous. We should therefore be able to recognize the analogy between Kant's *Dinge an sich* and what we have called the World of Knowledge, between the categories of thought and what we have called access procedures, and finally between the world as we perceive it and the world of knowledge as we code it internally. If we acknowledge that contemporary cognitive science is indeed a direct descendant of transcendental criticism, the humanities may indeed claim an important, fundamental and lasting influence on the information revolution.

## Notes

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24. See e.g. Hofstadter, D.R. *Gödel, Escher, Bach; An Eternal Golden Braid*. Brighton: Harvester Press, 1979.
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## HOW TO CONNECT A LIBRARY WITH A MIND

### Postscript 1985

The story I told in *How to Connect a Library with a Mind* originated, early in 1982, from an invitation by the Director of the Royal Library in The Hague to participate in the festivities around the official opening of the Library's new housing. The opening took place in September 1982. Since then, and before the text of this paper finally appeared in print, several relevant things have happened, two of which I wish to mention very briefly.

In the first place the problem of structural specificity of cognitive domains, preventing the design of a 'general purpose KIC' (knowledge interfacing chip) has come under close scrutiny in theoretical psychology and is currently the subject of a lively debate about the fundamentals of cognitive science, and cognitive psychology in particular.

Secondly, I have discussed with several friends, colleagues and miscellaneous readers of *How to connect...* the potentially malignant growth of the information requirements of our data banks or knowledge banks. Signs of this are already visible, for instance in the inconsiderate requirements gradually being imposed by bureaucratic entities on the next lower levels in their hierarchies. In this respect we may learn from the interaction between terrestrials and the Fred Hoyle's SF novel *The Black Cloud* as described in *How to connect...* (p.144/5). Since, relatively speaking, there is no speed limit anymore on the actual processing of data inside a bureaucracy, devastating effects may be expected at the input-output level: the executive levels in the organization will increasingly fail to implement the results of processing the data fast enough. With others, I am deeply concerned about the consequences of that development.

The proper way out, in my opinion, is to establish a legal framework, a communications protocol at the level of the social system, that imposes strict limits on the number of times, a particular computation may be carried out. Infringements will have to carry heavy sanctions. As an example, consider the fact that in the past the annual budget for a large organization—say, a university—was computed once, or at most twice a year. Computer programs now allow a recomputation several times a day (and sometimes I get the uneasy feeling that this possibility is indeed already being used almost to its full extent!). I propose that under future legislation, such *ad hoc* recomputations will be recognized as unnecessary and harmful to human freedom and dignity. *Annual* budgets will have to become again what their names suggest, and similarly the rate of recomputation and updating in other domains will have to be limited to what is reasonable. Only then humankind will be able to pick the fruits of the information processing revolution. That is, information technology is supposed to the drudgery out of administrative work and allow us to treat administration as a means rather than an end.

John A. Michon  
Haren, 8 May 1985