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ABSTRACT

Human individuals, social organizations and societies are alike in that their knowledge of past events is to some extent maintained and brought to bear on their behavior. On the individual level we know quite a bit of how this is accomplished. However, on the social level we know close to nothing. It is not the task of this paper to ascertain the reasons for this notable lack of knowledge, rather, to explore concepts that would overcome it and to point to some phenomena that might thereby become transparent. And because this is in a sense a step into no-man's land, a major portion of this paper is devoted to introductory topics, that is, to questions regarding memory, information retrieval by computers, etc. with lesser space devoted to elaborating the properties of different kinds of information storage and retrieval in society. (Author/SJ)

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SOME PRINCIPLES OF INFORMATION STORAGE AND RETRIEVAL IN SOCIETY

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August 1973

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Content

Introduction

Human individuals, social organizations and societies are alike in that their knowledge of past events is to some extent maintained and brought to bear on their behavior. On the individual level we know quite a bit of how this is accomplished. Studies of learning and forgetting are almost ancient. We have come to simulate short-term and long-term memories and are able to describe how some of the information is coded in the process. Chemical and neurophysiological studies of the brain are producing increasingly detailed insights. However, on the social level we know close to nothing. It is interesting to observe that Kenneth Boulding (1966) who put forth the proposition that "behavior depends on the image" which organisms have about their environment stops short of generalizing the notion to social phenomena, presumably because social organizations and societies are not nearly as solid and stable in structure as biological organisms or mechanical devices are. It seems difficult to maintain the wholistic concept of an image when its material basis is in constant flux. Additional barriers to such attempted generalizations may lie in the belief of the supremacy of individual cognition over social processes.

It is not the task of this paper to ascertain the reasons for this notable lack of knowledge, rather, to explore concepts that would overcome it and to point to some phenomena that might thereby become transparent. And because this is in a sense a step into no-man's land, I will have to devote more space than normally required to introductory topics, that is, to questions regarding memory, information retrieval by computers, etc., leaving only little space for elaborating the properties of different kinds of information storage and retrieval in society.

I might add that the reader who wants to start with additional justifications for the proposed conceptualization might begin with the last section of this paper.

Social Memory

The concept of memory comes to us from psychology where it serves certain functions in explaining human cognitive behavior and from biology where it has in addition a clear location and physiological reference. In society, the function of maintaining past information and its material base is less clearly identifiable. Nevertheless, certain obvious functional similarities have suggested an extension of the notion of memory into this domain. For example, many authors have likened the libraries of social organizations to the memories of living organisms and the electronic search for stored items of information to an individual's attempt to recall from his past experiences. Others have suggested that the growth of sharing scientific information across national boundaries is a process toward the development of a terrestrial mind, which may assume control functions similar to those of the brain within a biological organism.

Unfortunately, most of these verbal analogies merely relabel well known phenomena. Except for the intellectual puzzlement this might create, there seems little to be gained by calling an organization's network of communication its nervous system and the decision making elite of a country the nerve centers of its brain. Analogies should be judged by their productivity in facilitating the transfer of knowledge between two empirical domains. If the homomorphism between the two domains is not well established, which is quite usual in verbal discourses, then analogies are susceptable to two kinds of errors: errors of commission appear when irrelevant information is imposed on the target domain and errors of omission appear when the information that is transferred covers

only a part of what it pertains to. For example, with an organismic conception of memory in mind researchers are more likely to look for and find information storage phenomena that are highly centralized as libraries are and that use semi-permanent storage media as in the form of written records. Memory phenomena that are distributional or transient in character are thereby omitted. It is because of the uncontrollable nature of these errors that I prefer to start with a general definition of memory and not with analogies of this kind. The clearest definition of memory and a test for whether a system - any system - exhibits this property can be found by Ashby. Being concerned with the analysis of a black box, it is only natural that he takes the position of an external observer who wishes to understand and to predict from what he observes rather than that of an introspective participant. Memory, he argues, becomes manifest whenever the behavior of a system is influenced by events that lie sometimes back in the past and information about them must have therefore been retained within the system in some way. More formally and in his own words:

> ...if earlier events $E_1, E_2, \ldots, E_k$ leave traces $T_1, T_2, \ldots, T_k$ respectively, which persist; and if later the remainder of the system produces behaviours $B_1, B_2, \ldots, B_k$ corresponding to the value of T, then the various behaviours may be related to, or explained by, either
>
> (1) the present value of T, in which case there is no need for the invocation of any "memory", or
>
> (2) the past value of E, in which case the observer is compelled to postulate some form of "memory" in the system. (1956;116)

It is clear from this definition that "memory" cannot be attributed to the system being analyzed. Rather, it is manifest in the observer - object relation, that is, in the observer's inability to obtain full information about a system of interest and his need to fully explain and to predict.

> ...to invoke "memory" in a system as an explanation of its behaviour is equivalent to declaring that one cannot observe the system completely. The properties of "memory" are not those of the simple "thing" but the more subtle "coding". (1956;116)
>
> ...suppose I am in a friend's house and, as a car goes past outside, his dog rushes to a corner of the room and cringes. To me the behaviour is causeless and inexplicable. Then my friend says, "He was run over by a car six months ago." The behaviour is now accounted for by reference to an event of six months ago. If we say that the dog shows "memory" we refer to much the same fact-that his behaviour can be explained, not by reference to his state now but to what his state was six months ago. If one is not careful one says that the dog "has" memory, and then thinks of the dog as having something, as he might have a patch of black hair. One may then be tempted to start looking for the thing; and one may discover that this "thing" has some very curious properties.
>
> Clearly "memory" is not an objective something that a system either does or does not possess; it is a concept that the observer invokes to fill in the gap caused when part of the system is unobservable. The fewer the observable variables, the more will the observer be forced to regard events of the past as playing a part in the system's behaviour. Thus "memory" in the brain is only partly objective. No wonder its properties have sometimes been found to be unusual or even paradoxical. (1956;117)

Informally, we are likely to speak of an organism as having a "memory" whenever we find functional reasons for that organism to be incompletely observable and whenever the "memorized" information is physically or chemically localizable at least in principle. But in using this notion, we are neither able to prevent imaginary functional reasons to cover observational inadequacies nor are we able to go beyond the biological concepts which might not be appropriate in explaining social phenomea of memory. Asby's definition, on the other hand, leaves room to discover the unusual.

For example, it might seem far fetched to attribute the possession of memory to an object in motion because an understanding of its trajectory requires reference to more than one of its preceeding locations in space. But we know very well that the circumstances that have set an object in motion may continue to determine its path for some time to come. Without the knowledge of the prime mover, it is only natural to be lead to an explanation of motion in the nature of the object being observed. Physicists would not shy away from saying that objects maintain their direction and their momentum. And this is nothing other than an explanation involving the possession of memory. As Gerard (1963) once pointed out, it is perfectly legitimate to say that the callous hand of a worker memorizes past manual labor just as the shape of a deformed tree may be said to memorize the direction of the wind to which it had been exposed.In all these cases the mechanisms underlying the maintenance of past information is clear and simple. Social phenomena too are often seen as determined not by the present conditions alone but also by "historical forces" which is another way of saying that past events shape through some existing mechanism what is observable at present. It is the underlying processes by which traces of past events are maintained and brought to bear on the behavior of a system which I would consider as constituting its memory. These processes need be neither simple nor obvious but this should not prevent one from trying to uncover them.

Perhaps the term "social" memory still requires special attention here. I see such memories contrasted with organic and with artifial memories. Clearly small groups, social organizations and societies contain human individuals who carry with them experiences that are stored in their respective brains. Not-

withstanding the motivation for and the consequences of storing information individually, the process of memorizing past information from individual storage is essentially governed by the psychological laws of the human organism, not by social considerations. Similarly, many small groups and virtually all larger social organizations and societies incorporate in addition innumerable technical devices for storing information. For example, currencies and other accounting devices such as filing systems, libraries and not to forget, computerized data banks. These devices are essentially man-made and follow in behavior the laws of information processing technology which are not social either. To be sure, organic and artificial memories may have considerable social consequences. For example, the slow decay of ethnic prejudices due to a lack of reinforcement may influence the direction collective actions toward minorities may take. Or the increased efficiency with which computers retrieve and analyze data from the past may affect not only the pace of life of many people but also social structure. But social consequences of this kind do not themselves constitute memory. Their net memory effect is then reducable to the underlying organic or technical processes which are not my primary concern.

I want to go beyond this traditional approach which is so much rooted in psychological or in engineering assumptions and assigns to the fabric of society the mere passive existence of a channel through which memorized information surfaces. I want to include as explanations for the memory of a system the peculiar symbiosis between men and machines, the social conventions that place individuals into social structures and above all the social processes of communication. These are all processes that go beyond the

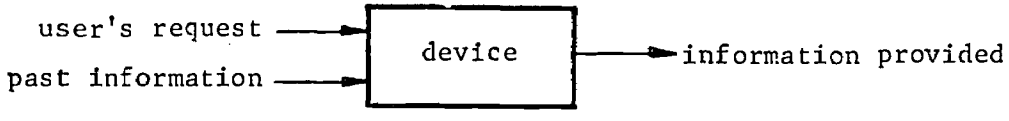
scope of the individual or of man's creations and are super-individual in character. I would say that a system possesses social memory if its history determined behavior can be explained neither by the psychological processes of its human constituents nor by the technological processes of the machines being used, but by reference to the underlying super-individual processes. It is presumably because these processes have so slowly grown and because our own social behaviors take involuntary part in it that we know so little about the social forms of memorizing information. But in order to understand the behaviour of larger social aggregates we might not be able to omit accounts of social memory.

The problem now before us is to identify the presence of memory by conformity of a situation with the formal definitions and to examine the structure of the processes that account for the way information about past events is maintained and brought to bear on the given situation We thus study neither a particular class of objects, people or social groups nor some of their behavior, rather we seek explanations of the quality "possessing of memory" in the very structure of the system to which this can be attributed. Social memory then is a form of explanation of behavior which is reducable neither to the psychological processes of organic memories nor to the technical processes of artifically designed mechanisms. Social memory explains history determined behavior by reference to structural features of society.

Information Retrieval by Computers

Mechanical devices have the analytical advantage of being structurally transparent in the sense that the assembly of their parts and the processes they thereby embody are rationally planned and under the conscious control of a designer. It is for this reason that it has always been appealing to learn from the way machines operate that bear functional resemblance to the behaviors of interest and to attempt a translation of technical knowledge into the domain of the objects that need a better understanding. For example the knowledge about electronic computers which have been used to replace certain cognitive tasks in production and management has also been used to shed light on human cognition itself (See for example Miller, Galanter and Pibram, 1960). In view of this analytical advantage let me review the major conceptions of artificial memories as reflected in the information retrieval literature.

Literature on information retrieval is concerned with the principles for designing devices that store information and respond to user's requests by making the desired information available. Because the information which such devices provide upon request is a subset of the information given to it beforehand, information retrieval devices may be described as a kind of selection aid. There are two principal inputs, the user's current request and past information which tends to be too voluminous to be examined in its entirety, and one subsequent output, the information provided. Graphically, information retrieval devices may be depicted as follows:



The development of information retrieval devices has taught their designers first of all that past information needs to be unitized into items which can be manipulated separately and are thereby regarded as logically distinct. Such items may be whole books, research reports tapes of lectures on television shows, even sentences or words qualify.

Secondly, substantive information or data of the kind a user may need to solve a given problem is representable only indirectly through class-markers indexes or by certain properties. To obtain such representations involves processes of classification and indexing which usually rely on an individual's ability to comprehend the data in question. The existence of automatic indexing and abstracting devices should thereby not be ignored. The use of the Linnean System of classification in biology is a classical example. Indexing medical records for computer processing, coding research results into machine readable form, applying thesauri on the words in political documents, all involve classification and indexing.

Classification and indexing is also the primary determinant of the structure of the stored information. Properties that are not represented in the available indices, relationships that do not appear as explicit links can not be operated upon and are therefore neither searchable nor retrievable intentionally. The structure of the stored information is therefore crucial in determing the kind of information that can be brought to bear on a given problem.

Thirdly, because items of information are usually too numerous to be examined in their entirety, search procedures are employed to work through the volume of stored information in such a way that irrelevant items are by-passed rather quickly. In computers, search procedures are intimately connected with the way information is classified and indexed. Most systems of classification are hierarchical in nature, allowing the search to proceed from the most general to the most specific class-markers.

Fourthly, and this is in a sense the complement to classification and indexing, the original data, the substantive information which is indirectly represented within a system must in some way be reconstituted and this invokes processes of retrieval. Retrieval may be accomplished in numerous ways. The image of a book page may be reproduced on a screen for a researcher to read, the tape of an interview may be replayed for a secondary analysis, and it is also conceivable that filed documents become available for examination in their original form. The page number of a book, the name of a tape, or the color code of a file are aids to locate records which allow a user in turn to retrieve substantive information or data.

The prototype of most information retrieval devices and the one that has served as a model for most computer applications in the field is found in almost all traditional libraries. A library stores information in the form of publications, that is, books, documents, maps, films, tapes, etc. These are the items of information which are separately numbered, independently catalogued and individually available to a user. As its holdings grow in number, a sequential search through all stored items quickly approaches practical time limitations. Even moderately sized libraries therefore provide the user with a search aide: the

subject matter catalogue which lists all items of information according to a classification of their contents and provides references to their location. In order to make use of this device, the user must be familiar with the system of classification, particularly, he must understand what each class-marker represents. The search procedure is then manifest in the interaction between the user and the catalogue, the user providing sequential judgements of relevance, the catalogue determining the order in which these are applied. Once class-markers are judged relevant for a problem at hand, the publications so indexed have to be located according to the references the catalogue provides. The retrieval of information from located items may begin with an examination of the table of content of a book, and with reading the proporition that is actually needed. But the latter procedures are very much outside the concern of a library. They involve distinctions finer than the items stored. Although the use of a library card catalogue is certainly much more complex than I can describe, it illustrates the principal features: item differentation, classification and indexing, search procedures, and retrieval of information. Literature search by computers is not much different from the above except that the system of classification and the procedures employed must be more rigidly defined and avoid intuitive judgements which are crucial otherwise.

I must emphasize that these conceptualizations are neither natural nor the exclusively only ones. For example, regarding the distinction of past information into separate items, it is quite possible to think of knowledge wholistically, as an organic web of propositions about the world. The fact that such a conception does not lend itself to efficient computation merely reveals the technological bias of information retrieval conceptions.

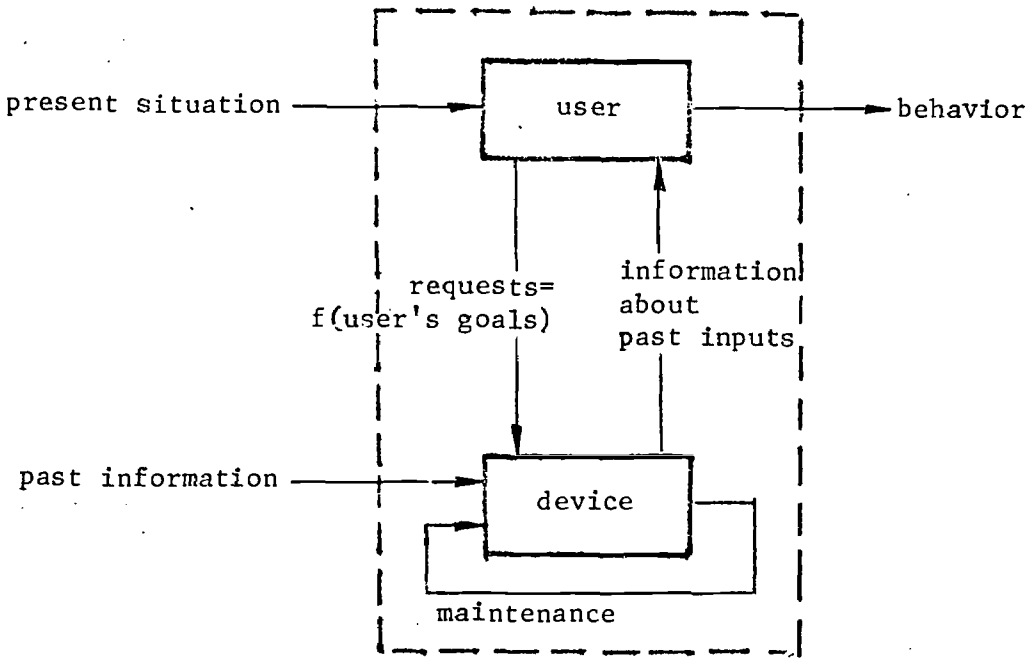
Classification and indexing is not a conceptual necessity either. It should be regarded as a way of packaging substantive information into easily representable items which may be convenient to the digital nature of computers. But information from the past can also be regarded as a continuous stream, like a many dimensional movie.

In this connection one is reminded of Bar Hillel's (1964) useful distinction between data providing systems and reference providing systems. Most of the existing devices search only for references to literature according to a variety of categories among which subject matter categories are the most prominent ones. The user then gets a kind of overview over the literature which might contain what he is looking for. However, the recognized goal of information retrieval is to provide information directly and in the form it is needed. This is not an easy matter. Question-answering systems (answering such questions as: What was the score of the last match between X team and Y team, or, which chemical analyst can break A into B plus a residual set of components) are still very limited in scope. As Bar Hillel has pointed out the requirements to achieve the two kinds of aims are somewhat conflicting and the respective usefulness of either system depends in part on how much one knows about the problem to be solved. One must come to the conclusion that the conceptions developed in the information retrieval literature are far from being unambiguous, perfect and final. They may nevertheless offer useful explanatory aids to approach problems of information retrieval in society.

Whether information retrieval devices of the kind discussed above constitute memory by themselves is an interesting though somewhat academic question. The answer depends of course on whether such devices do not merely

respond to a user's request but have some impact on some behavior. However, it is always so that in the coupling of a user to a suitable information retrieval device either more past information is utilized for solving a current behavioral problem or past information is brought to bear on current behavior in timelier ways. For example, successful solutions to research and development problems are more likely forthcoming with than without the aid of a computerized information retrieval system. The computer system above cannot do much other than selecting from what is stored. But when this enables a researcher to consider for his decisions a longer history of the events that lead up to the present situation can the man-machine combination be regarded as possessing a memory. Similarly, a library alone may well be regarded as an intellectual graveyard unless something is being done with the information therein stored. An organization in government or in business which makes use of an adequate library is less likely to repeat previous mistakes in dealing with its environment than one without such a storage facility. Information retrieval devices can thus make a large system more history determined. They themselves offer only one part of an explanation of memory.

Graphically one may depict the situation as follows:



It is the user who behaves as a function of both the current situation and information provided from the past. Information retrieval devices store information about past events and respond to the user's request by making past information selectively available. Memory then becomes manifest in the man-machine interaction which the user typically initiates.

Without making a commitment to the terminology of information retrieval devices, one can distinguish at least the following processes:

(1) Acquisition, that is, processes by which information enters an organism or organization. In human terms this would include selective attention and perception. In the information retrieval literature this would include classification and indexing though the motivations for acquiring certain information are rarely discussed in this literature.

(2) Storage and maintenance including the decay of past information within an organism or organization. Again in human terms this could involve processes of reinforcement and forgetting. Social organizations tend to devote much time and energy to keeping files in order and information retrievable. In digitel computers the problem is virtually eliminated because of the either-or character of its storage media.

(3) Search, that is, processes that operate on stored information so as to select what is relevant to a given situation, or problem.

(4) Retrieving, that is, processes by which information is reconstituted or reconstructed and made available. The most obvious example is of course the reading of documents for what is encoded in them.

These distinctions exclude processes by which something becomes recognized to be a problem requiring past information for its solution and processes of decision making involving available information. But I believe these are not so central to the concern with memory and are well understood isolated from this concern.

In the following I will elaborate on three ways information is stored and retrieved within the fabric of society;as temporal memory, as structural memory and as special memory. After these forms have been described I will differentiate between hierarchical and associative search procedures in society. As

I argued above, the lack of literature on the subject matter can make this treatise merely scratch the surface of what needs to be done.

Temporal Memory

When one thinks of stored information, one is too easily lead to think of books, of punchcards, of records, of magnetic tapes, and the like. Here information is stored in a medium which bears certain specially coded characters. In these examples, it is respectively the alphabet, an arrangement of holes, the curves of a spiral grove, and the direction in magnetism of ferromagnetic particles. Such media can be manipulated without retrieving the information therein contained. But many social processes that maintain information exhibit no records whatsoever. Consider how folktales, myths and song in illiterate societies or rumors are passed along from one person to another without ever being written down. True, the individuals involved have an organic memory of their own and will remember at least for a short time. However, the fact that a society maintains information of this kind beyond the life span of its individuals may just be due to its being continously transmitted. The individuals do not need to remember the information as long as they pass it on or as long as it always travels at least somewhere. Memory is then explainable by the very process of transmission during which information is retained in a temporal code.

Actually, there are even some computers that store temporally coded information. One such species consists of several mercury filled tubes, about one meter in length. At one end information is transferred to the mercury in the form of ultrasonic impulses and by means of a kind of loudspeaker these impulses then travel through the mercury to the other end where they are picked up by means of a kind of microphone. From there the impulses are electromagnetically transmitted to the starting point. This process is repeated indefinitely until the circular process is interrupted. While the information is circulating, it can be intercepted before or after each passage through the tube.

A closer examination of this device reveals that its over-all memory is actually the result of very many infinitesimally small transmission delays in the mercury atoms. Each such atom passes on what it receives to its next neighbor. But before it does respond, it must be induced to do so by the very impulses it is to transmit. For the short time period until a mercury atom responds, it maintains the impulses it receives. For each atom, the capacity to so store information is extremely small or virtually zero, but the net effect of a long chain can be sufficient to maintain a significant quantity of temporally coded information.

Furthermore, the sequences of operations which are applied on the input information and thereby transform it from one moment into another adds up to an identity transformation. Only if this is the case can the information be maintained for some time. If it does not add up to an identity transformation, the information trapped in the reverberating circuit becomes progressively polluted by noise or systematically distorted.

Just for fun, I once tried to catch information within a closed circuit television system by focussing the camera onto its own monitor. A quick hand movement introduced between the two became repeated over and over again until it was eaten up by the tremendous noise to which such a system is susceptible. I might add that it was not easy to find a suitable camera position in this case which would not either successively magnify or reduce the image in question. But this is a peculiarity of the technology. The principle of information storage seems thereby demonstrated.

The fact that these technical devices store information whenever a sequence of transmissions (1) involves small delays and (2) adds up to an identity trans-

formation points to the possibility that social forms of orgnizations might also possess temporal memorieson the ground that they are held together by processes of communication among individuals. This need not be so by design but as a consequence of the fact that individual members communicate with each other. Transmission delays are the norm in human communication and accurate transmission which might not always be achieved is nevertheless a possibility.

For a society to memorize its folktales, myths, songs and even its rumors, there is no reason to assume that they need to be recorded or stored in their entirety in the minds of human individuals except for the very short delays required to translate, to reproduce or to react to what each receives. With the model of a temporal memory in mind one is inclined to suggest that such information is either not individually remembered at all or rapidly forgotten by the individuals involved unless it is restored by repeated tellings. For the reality of this process there exists some evidence. In order to explain how the cultural heritage of a people is maintained there seems to be no reason to assume that its contents must be written down nor is it necessary to assume that the individuals involved share it or understand the larger meanings of it. Cultural heritage may well be regarded as a body of past information which has survived the interaction with the individual problems of every day life and is found to be in a continous process of transmission from one individual to another including from one generation to the next. It is maintained not because it is useful for society - a possibility that need not be denied - but because the existing channels of interpersonal communication continue to let it circulate repeatedly.

The way the contents of a temporal memory can be erased provides an important test for the existence of temporal storage. By erasing the contents of such a memory

I do not mean the successive distortion of information in the process of transmission. This phenomena will be returned to below. But there is also the possibility or danger of a temporal memory to be erased at once. For example, when the power supply to the mercury computer is cut off the information that circulates within it ceases to exist completely. Temporal social memories behave no different. When communications processes between individuals are completely interrupted for a period in time that exceeds the transmission delays, temporally coded information ceases to remain memorized as may be seen to have been the case with American blacks who were prevented by their white masters to maintain that body of information which was so central to their identity before they became slaves. In society, complete interruption of all communication processes is very unlikely. However, with regard to selective content areas, this may well be accomplished, particularly where there exist strong social restrictions against transmitting certain kinds of information or where an authoritarian government can prevent certain kind of messages to be exchanged.

The analogy to processes by which communicable diseases maintain themselves is particularly appealing. Here too, if transmission could be stopped for a certain period of time communicable deseases would become extinct at once and forever. Since we have not been able to apply this treatment for obvious reasons we will have to carry with us part of what our ancestors could not prevent to enter the ongoing intra human bacteriological transmissions.

I should like to add that serious consideration has been given to hypotheses suggesting that the memory of animals and man might be based on a similar principle. Various brainwaves seem to indicate a continuous activity and the delayed firing of neurons in response to impulsesfrom other neurons is an established fact. However, after electro-convulsive shock therapy, or after an epileptic seizure, a patient's brain is often electrically completely inactive for a period of several minutes but long term memory is

not thereby destroyed as would have to be expected if all information would be stored in temporal code. Thus a reverberating circuit cannot be the exclusive basis for organic memory. Man's short-term memory, on the other hand, may well conform to this principle of information storage.

With reference to social phenomena one can entertain the similar hypothesis suggesting that individuals have no memory of their own except for a complex information delay function and that history is stored entirely in the social fabric connecting them with each other. In view of our knowledge of human organic memory, which is almost always involved, this hypothesis cannot be supported in its generality. But our knowledge about processes of communication and about the way certain information can irrecoverably drop out of the stream of transmission - the cultural heritage was taken as example - suggests that temporal memories are significant in explaining a large class of social phenomena.

Retrieval from temporal memory involves interception of the flow of information and because of the temporal code implied in the transmission processes, the possibility of retrieving information in this way tends to be limited to specified locations within the communication network and to certain points in time. In the mercury computer, for example, information is unobtainable while it travels through the mercury tube. To intercept it one must await the beginning of the message to appear at the exit point of the mercury tube. Also in social organizations, many linear processes are set up in such a way that they maintain the information about their initiation until a condition for termination is needed. These terminating conditions are then the natural or regular interception points.

The postal service which transports mail between geographically distant places provids an obvious example of such an arrangement. Of course, of some

pieces of mail records are kept and the written addresses cannot be ignored for routing the mail through the right channels. But this is of no concern here. Once a letter is posted, processes are initiated that take their due course without the possibility of their being interrupted or monitored by the sender or by the receiver until it reaches its designation. What the postal service maintains is the frequency and time ordering of the posted mail. Responses to a provocative television program or to a local disaster or ethnic habits involving written communications are irretrievably memorized by the postal service until they reach the destinations: television stations, government officials or friends respectively.

How difficult it is to intercept information that is memorized in temporal code can also be seen in the following incident. In 1971, when the military suppression of Bengalis was at its height, many responsible U.S. senators and congressmen wanted the flow of military goods to Pakistan stopped and the administration indeed declared this foreign aid cancelled. After a journalist's discovery that ships were still sailing with arms and ammunition on board, it was learned that these had been in the pipeline for some time. Because of the long delays between the government's approval of the sales and the delivery and because of the diffusion of this information within the military-industrial networks, the U.S. government could not easily intercept what was in the process. The pipleline probably never dried out, it was not designed to be monitored.

Any process of transmission is of course suceptible to disturbances from extraneous sources and because information in temporal memory is always in the process of transmission, disturbances may successively destroy the stored information. The noise in the closed circuit television mentioned above is an example of this phenomena. Additions to and deletions from the cultural

heritage through encounters with new problems and techniques of coping with an environment is another. In either case, information decays as it is transmitted. But the two examples also demonstrate that such decay is not necessarily undesirable. In the case of the mercury computer this may well lead to wrong conclusions. But, if the cultural heritage of a society would not slowly adjust to changing circumstances, that society might soon find itself unduly constrained by a history of events that is not any more relevant for coping with current social problems. Evidently in the absence of clearly stated aims it is impossible to decide whether the decay of information from temporal memory is purposive.

Negative feedback which we know to be essential for all purposeful activity of man offers numerous examples for the systematic loss of temporally stored information. First of all, feedback means circular flows of information: actions result in consequences, some evidence of these consequences are feed back to actor, available evidence modifies further actions, etc. The information inside such a circular processes, including possible errors or extraneous variations, is somewhat protected against outside interferences. Secondly, negative feedback means that the circulating information becomes increasingly correlated with given goals: actions become increasingly effective, errors become less and less frequent. It follows that negative feedback has the tendency of selectively weeding out undesirable information and maintaining only information that is desirable or, in the special case of a perfect regulator with a fixed goal, no information at all. Therefore, while one cannot infer purpose from the decay of information one can anticipate a certain loss of information when the flow is governed by purpose. On the other hand, positive feedback in the information flow has the tendencies of amplifying temporally coded information selectively, possibly beyond

recognition, the mushrooming of a rumor being a case in point.

As a last point, one might consider on what the quantity of information depends that a temporal memory can hold. Obviously crucial is (a)the information storage capacity of the transmission delays involved, and (b) the net arrangement of these delays. In the case of the mercury computer the delays are extremely short and the amount of information that an atom can store is infinitesimally small. But the chainlike arrangement of these small delays accounts for the fact that individual capacities are additive and result in a storage capacity that is sufficient for the purpose. In society, the longest transmission delays are probably caused by human communicators. But what accounts for social memory is primarily their arrangements into networks of communications which are governed by laws of social organization. One might not yet be able to quantify the information which a temporal social memory may store, but one can say that this quantity is positively affected by the length of the existing communication devices and by the length of the delays (with the individuals life span providing the upper limit). I'd like to note that the reverberating circuits of society usually maintain much more temporally stored information than one is willing to give it credit for. Consider only the long half life of national and ethnic prejudices, ideological outlooks and governmental stereotypes or the long range consequences of corporate actions within the fabric of society. The current ecological crisis exemplifies that nature's temporal memory too is likely to be underestimated in its information storage capacity: collective actions taken a long time ago have slowly yielded threatening consequences by adding one slight change to another and by setting in motion causal chains that have affected nearly all species and features of the physical terrain. Nothwithstanding difficulties of information

retrieval, an environment memorizes many of the actions that social organizations initiate, most likely not in their original form, but until all of their chain effects are worn out. And this may involve time periods of considerable duration.

As may be imagined, the retrieval of this conceivable wealth of information is generally severely restricted. It must be intercepted when, where and in the form it is transmitted. Therefore, one barrier is limited access. In addition to the examples given above one might mention the well known observational difficulties that cultural anthropologists experience when a society prescribes for its members the occasions at which the transmission of cultural heritage is regarded as proper. Prescriptions regarding "who is allowed to tell what to whom" amount to designating specialized storage areas whose location must be known to be tabbed. Or, consider the difficulties of retrieving information about an ongoing advertising campaign. No agency can gain information about success or failures unless and until the market "is willing" to respond visibly whether in the form of sales or in the form of reactions to the appeals being made. Often the signs are too weak to be recognised, remain hidden for some time or are confined to a locality where one does not expect them to reverberate.

A second barrier lies in mapping the intercepted information into a form comparable with the original. In the mercury computer the transformations are designed to add up to an identity mapping through which all information is maintained. This can hardly be achieved in society. Themes of a once popular song may become incorporated in folk literature from where they may be picked up and transformed into an advertising slogan, which subsequently modifies

consumer behavior, which in turn effects the design of a class of products, etc. If this is indeed a chain of influences with information added, deleted and transformed, the problem is to recognize what is relevant in whatever form information is intercepted. Purposive organizations are of course constantly engaged through research or other methods of monitoring their environment in trying to gain insights about what their own cause of action does ultimately to themselves. To accomplish this aim requires modes of the environment through which the effects of an organization's behavior is transmitted. Because such models are rarely available, incomplete, or too simplistic the wealth of information that is temporally stored within the fabric of society is difficult to retrieve in fact.

Let me summarize the principle features of this method of storing information. Its defining feature is that past information is retained not in the form of spacially coded physical records rather in sequential or circular processes of transmission that involve many small delays. The net effect of such a process is that temporal patterns of variation at some imput are maintained for a long period of time, particularly when the flow of information is circular. Social organizations possess temporal memory by virtue of the fact that its members communicate with each other, affect each other's behavior or participate in long chains of consequences. Information is maintained as long as it is being passed around.

Naturally, processes of transmission are particularly susceptible to disturbances such as noise, additions, deletions or super impositions of information. The maintenance of a temporal memory may require protective efforts against possible influences by extraneous sources.

The retrieval of temporally stored information involves intercepting the transmission process. Interception is possible only at particular

times typically yielding only the transforms of the original information which must be interpreted. In society, the limited access and the difficulties of decoding intercepted information present the main barriers against utilizing temporally stored information. The resistance against intercepting ongoing information flows seems to increase with the increasing complexity and purposiveness of the network of communication storing it. Intelligence departments and research operations in government and industry are manifestations of these difficulties.

Temporal memories may have a life of their own. When information is not intercepted in time it may get irretrievably lost. When it is not protected against disturbances it may evolve into something unrecognizable. When it is not controlled it may come back as a threat. When communication is interrupted for a sufficient period in time, the whole memory may be destroyed.

Memory involving Records

Another very basic and fundamentally different way of storing information relies on semi-permanent changes in a medium which thereby carries into the present some information about its past history. Most obviously, this method of storing information is employed intentionally whevever someone commits his thoughts to writing, whenever something is recorded on film, and whenever data are punched on Hollorith cards or read into the core memory of a computer. In these examples, information is stored spacially, i.e., by a spacial arrangement of physical characteristics and with the knowledge that it can be reproduced when needed. What is maintained over time is a record of past events. That records of this kind are the pillars on which much of modern information technology is built needs no lengthy demonstration. Also that much of the workings of society -from bookkeeping to art - relies on physical records is quite evident. However, the principle of memory involved is restricted neither to an intentional process of recording nor to the more or less faithful reproduction of the information from the past and in fact, the mere spacial representation of an event alone does not constitute memory as will be seen below.

Allegedly, Ralph Gerard taught his students about memory in biological organisms by pointing out that "linseed oil remembers...because, if linseed oil is exposed to oxygen for a period of time and then put away for 10 years, its oxidation rate when returned to the air will be proportional to how long it had been originally exposed" (Pribram in Kimble, 1965: 9-10). But upon careful examination of the case, one will immediately recognize that linseed oil "remembers" neither by free will nor without the help of some outside observer who knows the function relating exposure time to oxidation rate. Suppose the observer employs a measuring instrument which incorporates the known oxidation function and indicates upon contact with any linseed oil how long it had been exposed. It is then not entirely rhetorical

to suggest that it is not the linseed oil that remembers but the instrument because the information thereby provided is primarily about the linseed oil's past history and only secondarily about the instrument, though the latter cannot be ignored either. The truth is that this form of memory is mutually conditioned. Neither the linseed oil nor the measuring instrument remembers by itself. But the combination of the two has this effect. And that something is memorized in the process is possible only because the transformation of linseed oil under oxygen exposure is matched by a measuring instrument which incorporates the inverse of this transformation.

Thus, in memories involving records, the arranging of physical characteristics in a medium and the retrieving of information from it are complementary processes. In the terminology of the communication researcher: encoding transformation account for the way records come about or events find themselves represented in a medium, and decoding transformation account for the way information about some antecedent conditions of the given record are retrieved. In technical devices for memorizing past information by this principle, the two transformations are invertible and one-to-one so that their proper combination becomes an identity mapping up to a small error. For example, the functions incorporated in machines for cutting a record (disk) and for playing it back are invertible, the error becoming manifest in acoustical noise. The two transformations involved in shooting a movie and in screening it are similarly related. In society encoding and decoding transformations are less perfectly related. Consider what is lost between writing and reading a book, between applying the make-up on a woman's face and responding to it, between burying a person and interpreting the surviving evidence on his grave. How encoding and decoding transformations are related to each other has social

significance in the sense that the combination, and not either transformation alone, determines what can, should or is in fact memorized and what cannot, should not or is in fact not memorized in society.

Encoding and decoding transformations are of course also the basic processes involved in making and using symbols. Symbols are often defined as spacially coded signs and symbolic behavior is said to be basic to man. The concern with social memories involving records is therefore intrinsically linked to the concern with language, meaning and communication - not with the media through which it is exposed, rather with how a medium is transformed, how the transformed medium is maintained and how it is utilized at a later point in time; - not with the syntax of the record, rather with the mappings of events into a particular spacial configurations and how these configurations are later transformed into the behavior of social aggregates. In other words, the concern with social memories involving records is a concern for the social processes that underly the transmissions of history through semi-permanent physical media in the broadest sense.

A not so obvious example for spacial social memories - the obvious ones would involve the traditional means of communication - may be taken from the social scientist's operational vocabulary. Sociologically, generations are said to define themselves in conjunction with certain significant events the experience of which is shared by and have lasting effects on the values, life styles or political orientations of a majority of similar aged individuals. Age groups which have suffered through the depression are easily identificable by certain attitudes towards the economy and towards government. Age groups who were drawn into the civil rights movement, into the peace corps, and participated in the politicization of campuses are marked differently by their collective experiences. In both cases,

the effects may last for a long time if not for life and constitute in a sense a semi-permanent record which individuals carry around and exhibit to others whether they want it or not. I should like to say that the way information is maintained in the generational division of society is not entirely reducable to the properties of the individual's organic memory. First of all, information about the events that are deemed central circulates among the "similar minded" people which points to the properties of a temporal social memory. But most importantly, information about these events become selectively reinforced and perhaps transformed so as to become self-defining vis a-vis another generation. And this process turns out labels, names and self serving social classifications. Labeling of individuals involves defining the socially significant physical or behavioral characteristics that are regarded as information bearing about social classifications and is nothing but a kind of record making process which is called encoding. Identifying a person with the generation, class or type to which he belongs then involves the proper decoding of these characteristics. If valid, the social memory processes also allow competent social scientists to retrieve to a degree better than chance a considerable amount of stored information from the individuals that conform to the operational indices of the generation in question.

Labeling, classification, typing is of course a universal in all societies and I would suggest that it is an operationally advantageous way of retrieving stored information. Labeling is a feature of social memory involving records. Consider the often permanent irreversibly progressive labeling of individuals as a function of their association with a social institution. Uniforms are the most obvious physical signs which tell the informed of what kind the bearer is. Even without a uniform names of titles or of positions, or names for the nature of an employment do much the same. For example, a professor must have passed

successfully through several educational levels and be recognized by a university as a contributor to an established academic discipline. The label professor, just as most other labels of individuals, serves as a record of its holder's past experiences and indicates certain accomplishments. In addition, the university as an institution carefully sees to it that it is applied only to individuals satisfying the prescribed conditions. Anyone familiar with the educational system within which the label is applied and protected against misuse is thereby able to decode some of the individual's institutionalized past experiences. In "coupling" a professor with someone who knows what a professor is, past information about the bearer of that label becomes effectively available just as the coupling of oxidized linseed oil with a proper measuring instrument provides information about the oil's history.

So far, examples have concerned memories in which the combination of physical records and proper decoding function makes the encoded information available to an individual user. But there are also many examples in which the information that is thereby retrieved becomes embedded into a process that reproduces super-individual behavior. Consider the social role as a sociological concept. Role taking too involves a kind of labeling or self-labeling of persons by virtue of their individual aspirations, qualifications, and capabilities or responsibilities to behave in a set way. Current theory suggests that social roles are definable only through their proper complements. Accordingly, the role of a teacher can only be defined in contrast to the role of a student and the role of a salesman is only meaningful when complemented by a potential buyer. In this way, when someone who sees himself in the role of a driver recognizes in another person's uniform a policeman waiving the car to the side, he has already decoded the informa-

tion provided by the uniform and gesture. Suppose he follows the command, it may now be the policeman's turn to recognize the driver as a long-haired hippy which "tells" him exactly what to do, etc. What follows is the acting out of two roles. Each decodes from his own vantage point what he can see in the other and incorporates this information into the premises for subsequent actions. To the extent the roles are normatively defined, the unfolding interaction sequence reproduces a behavior which society has acquired a long time ago. It is unique not to each individual involved but to the combination of their roles, each bearing complementary role markings. The combination of roles in interaction memorizes an interaction sequence and thus constitutes a social memory of super individual information.

One might speculate on the function of a memory in society that involves socializing individuals to assume different sets of roles. First of all, since the behavior of a combination of individuals depends largely on how they decode each other's markings, by facilitating the combination of some or by restricting the combination of other roles (amounting in fact to individual encoding and decoding transformations) different joint behavior will result. Thus, A to B may be like father to son, A to C may be like policeman to criminal, A to D may be like subordinate to superior, C to D to X to Y may be like the members of a Board of Directors, etc. So that each combination of individuals (each with their respective role set) may recall a different social behavior from the society's past. This allows a society first of all to exhibit considerable flexibility in activating information from the past. Secondly, by regulating the assignment of roles normatively, it enables a social organization to be somewhat independent of the individuals carrying out its behavior. Individuals may be replaced according to

whether they fit into a complex network of roles. Organizations can thus memorize advantageous organizational forms beyond the life of its individual members. Thirdly, there is no need to assume that the information thereby retrieved must fit into any single individual's head. A society which employs such a mode of storing information in a certain domain can afford its members to be myopic in that domain, leaving intellectual facilities for other activities.

Although this paper is not concerned with processes of acquiring past information, these processes and those of information retrieval may build upon each other in ongoing processes of communication. In its most simple form human communication involves encoding meanings into physical patterns or signs that are conveyed to be decoded by an addressee. In ongoing communicational exchanges the meanings of expressions are created and modified in the course of interactions so that the communication participants as well as the external observers who try to understand what a particular expression means will have to incorporate into their interpretation the history of the exchanges that led up to it. What A says to B is presumably a response to what B said to A before which was presumably a response to what A had said to B earlier, etc., so that the meaning of what A says to B cannot be decoded without considering the sequence of interactions that preceeded it. This clearly exemplifies the effects of a social memory and when one is concerned with what the patterns of sound mean one is concerned with records, with spacially coded information though the temporal aspect cannot be completely separated from it.

A good example from Carroll's Through the Looking Glass is the conversation of Alice with the Red and White Queen:

> "I'm sure I didn't mean--" Alice was beginning, but the Red Queen interrupted her impatiently.
>
> "That's just what I complain of! You should have meant! What do you suppose is the use of a child without any meaning? Even a joke should have a meaning--and a child is more important than a joke, I hope. You couldn't deny that, even if you tried with both hands."
>
> "I don't deny things with my hands," Alice objected.
>
> "Nobody said you did" said the Red Queen. "I said you couldn't if you tried."
>
> "She is in that state of mind," said the White Queen, "that she wants to deny something--only she doesn't know what to deny!"
>
> "A nasty, vicious temper," the Red Queen remarked; and then there was an uncomfortable silence for a minute or two.

In this conversation, each party elaborates on something the other asserted in the preceding speech act and thereby encodes parts of the sequence into what each expression means. Conversely, each expression carries with it much of how it came about. "She is in that state of mind" is virtually uninterpretable without resort to its antecednts and it is through this decoding process that social memory, though of a very short duration, becomes manifest.

Whenever encoding and decoding functions are not invertible and one-to-one, some information will be lost irretrievably and this may occur either in the process of encoding or in the process of decoding or in both. For example, unintentional records tend to provide information only about those events that are sufficiently forceful to leave their marks in a durable medium. Deserted fields and burned out villages may indicate the extent of a recent war but do not record the experiences of those who died in the process. The loss here occurs already in the process of encoding. Records may also decay over time or they may be overwritten by more recent events which means that information may not any more be decodable in full. Social memories are particularly susceptible to losses incurred from mismatching encoding and decoding transformations. Wrong inter-

pretations of available data, improper behavior resulting from combinations of non-complementary roles in interaction, incorrect identification of symptoms, etc. exemplify such losses together with the notion that they are undesirable. The latter is often regulated by institutions that are set up to guard against such losses, for example, the institution of Science, the various institutions protecting social conduct. However, such losses may well be important when past information comes of age in the sense of being not any more relevant to the present problems.

References to information losses imply quantitative notions and while the analogy to the noise in temporal memories is appealing, quantities of information contained in records may have to be obtained differently. Considering the above examples of information losses, the approach will have to consider the encoding and decoding transformations that respectively account for how records are made and how information about the antecedent conditions is retrieved from them. Chiefly, processes of encoding must be selective among the possible ways given events can be represented in a medium else information cannot be regarded as recorded. Similarly, processes of decoding must be selective among the given record's possible antecedents (or rather among the possible representations or consequences of these antecedent) else no information is obtained from the record. This selective aspect of information is well considered in semantic theories of information which provide a suitable starting point for quantifying memories involving records.

With this possible quantification in mind I would say, just as I did for temporal memories, social memories involving records are larger than one is likely to give it credit. There is the enormously large category of unintentional records.

All man-made things may be said to carry at least the marks of their maker and for the specialist they convey in addition information about their time and place of origin, the functions or dysfunctions they served, etc. Webb et al. (1966) recently discovered and wrote about the wealth of social science data that is in our physical surroundings: the wear on the footsteps of public buildings can indicate the frequency of their use, the gravestones tell stories about the growth, wealth and problems of a community, families, diseases, accidents. Social bookkeeping of transactions, birth and death records all contribute the physical basis of a vast memory which can be tabbed with some effort by developing proper decoding transformations. The advantage of such a memory is that information may be retrieved from it unobtrusively.

The situation is even more obvious when one looks at the ever increasing volume of written documents that technologically advanced societies leave behind: literature, actual accounts of events, operational records of business and industry and scientific findings increase exponentially. For the literary scholar, historian, manager or natural scientist respectively, this poses increasingly severe problems of information retrieval. For the social scientist who wishes to understand the behavior of social organizational forms (including that of individuals or institutions engaged in storing and retrieving information), this poses the problem of understanding the "historical forces" that shape current behavior as social memories with all of its flaws, limitations and facilitating devices.

Though I feel that the characteristics of a social memory involving physical records should have been demonstrated on more different and perhaps less obscure situations, let me summarize at this point: The defining feature of this kind of memory is that past information is encoded spacially and in a medium that persists in time. Physical records can be treated separately. They may be created intentionally i.e. with the view of their future use, or they may consist merely of the traces

of social events or physical correlates thereof. The encoding transformation that accounts for the way a record comes about may describe causal links, conventions or processes that are part of more complex social phenomena.

Memories involving physical records become manifest in the proper combination of at least two time-distinct transformations. Encoding processes must be matched at a later point in time with the complementary decoding processes else past information cannot be reproduced. When the two transformations are not invertible and one-to-one past information may not be recoverable in detail. It is the combinations of encoding and decoding transformations (not the record as such) which determine how much and what kind of information can be maintained in a memory involving physical records.

In society, records need not be written in a conventional medium. Past information may be "written" on a person's face, carried in uniforms or similar social markings, in the form of particular gestures or encoded into an architectural space. Interaction among individuals with its successive encoding and decoding processes may reproduce past information about which neither individual is aware.

In order to understand how historical events shape current social behaviors, it is important to account for how and which records are made and maintained in a social organizational form and what information they carry, as well as how and which records are interpreted and what information is obtained through them.

Structural Memory

Storing information in the form of physical records and retrieving it by decoding probably constitutes the most widely understood memory in society. As I argued above, libraries are the prototypes of this kind of memory, the design of recording equipment and most information retrieval systems conform to this paradigm, and when sociologists talk about symbolic processes they have similar conceptions in mind. Surprisingly, in biological organisms and perhaps also in social organizations this method of retaining past information for future use is by far not the prevailing one. Of course there is messenger RNA, there are blood cells and there are hormones which function as records in biological processes that thrive on past information. But this is not the only way a species (as distinct from an organism) acquires and maintains information. Earlier I argued that much of the past information available to a brain cannot be stored in temporal code. A similar argument can be made against the exclusiveness of memorizing by physical records. Neurophysiologists have not been able to find the equivalence of filing systems in the brain and records of the kind that we know exists in biological organisms seem to be limited to lower levels of cognition. In trying to examine the ways past information is retained in society one might start asking questions as to how organisms do store that information which enables them to react appropriately to the environments in which they live. Evidently, adaptation is a form of learning in which an organism improves in its way of coping with the problems it is faced with and in the process of adaptation, information about its environment is incorporated in its mode of behavior. Again, how such information is acquired is not my concern here, but how it is manifest within the organism is what has to be discussed

to establish it as distinct from temporal memory and from memory involving records.

Let me cite Heinz von Foerster, who argued in essence for the necessity of a structural memory in biological organisms:

> Let me confess that I am a man who is weak in properly carrying out multiplications. It takes me a long time to multiply a two or three digit number, and, moreover, when I do the same multiplication over and over again most of the time I get a different result. This is very annoying, and I wanted to settle this question once and for all by making a record of all correct results. Hence, I decided to make myself a multiplication table with two entries, one on the left (X) and one at the top (Y) for the two numbers to be multiplied, and with the product (XY) being recorded at the intersection of the appropriate rows and columns (Table 15).

TABLE 15

X·Y	Y: 0	1	2	3	4	5	6	7	. . .
0	0	0	0	0	0	0	0	0	. . .
1	0	1	2	3	4	5	6	7	. . .
2	0	2	4	6	8	10	12	14	. . .
X 3	0	3	6	9	12	15	18	21	. . .
4	0	4	8	12	16	20	24	28	. . .
5	0	5	10	15	20	25	30	35	. . .
6	0	6	12	18	24	30	36	42	. . .
7	0	7	14	21	28	35	42	49	. . .
.	.	.	.	.	.	.	.	.	. . .
.	.	.	.	.	.	.	.	.	. . .

> In preparing this table I wanted to know how much paper I need to accommodate factors X, Y up to a magnitude of, say, n decimal digits. Using regular-size type for the numbers, on double-bond sheets of 8 1/2 x 11 in, the thickness D of the book containing my multiplication table for numbers up to n decimal digits turns out to be approximately
>
> $$D = n \cdot 10^{2n-6} \text{ cm.}$$
>
> For example, a 100 x 100 multiplication table ($100 = 10^2$; $n = 2$) fills a "book" with thickness
>
> $$D = 2 \cdot 10^{4-6} = 2 \cdot 10^{-2} = 0.02 \text{ cm} = 0.2 \text{ mm.}$$
>
> In other words, this table can be printed on a single sheet of paper.
>
> . . .

> Now, I propose to extend my table to multiplications of ten-digit numbers. This is a very modest request, and such a table may be handy when preparing one's Federal Income Tax. With our formula for D, we obtain for $n = 10$:
>
> $$D = 10 \cdot 10^{20-6} = 10^{15} \text{ cm.}$$
>
> In other words, this multiplication table must be accommodated on a bookshelf which is 10^{15} cm long, that is, about 100 times the distance between the sun and the earth, or about one light-day long. A librarian, moving with the velocity of light, will, on the average, require a 1/2 day to look up a single entry in the body of this table.
>
> This appeared to me not to be a very practical way to store the information of the results of all ten-digit multiplications. But, since I needed this information very dearly, I had to look around for another way of doing this. I hit upon a gadget which is about 5 x 5 x 12 in in size, contains 20 little wheels, each with numbers from zero to nine printed on them. These wheels are sitting on an axle and are coupled to each other by teeth and pegs in an ingenious way so that, when a crank is turned an appropriate number of times, the desired result of a multiplication can be read off the wheels through a window. The whole gadget is very cheap indeed and, on the average, it will require only 50 turns of the crank to reach all desired results of a multiplication involving two ten-digit numbers.
>
> The answer to the question of whether I should "store" the information of a $10^{10} \times 10^{10}$ multiplication table in the form of a 8 1/2 x 11 in book 6 billion miles thick, or in the form of a small manual desk computer, is quite obvious, I think. However, it may be argued that the computer does not "store" this information but calculates each problem in a separate set of operations. My turning of the crank does nothing but give the computer the "address" of the result, which I retrieve at once—without the "computer" doing anything—by reading off the final position of the wheels. If I can retrieve this information, it must have been put into the system before. But how? Quite obviously, the information is stored in the computer in a structural fashion. In the way in which the wheels interact, in cutting notches and attaching pegs, all the information for reaching the right number has been laid down in its construction code, or, to put it biologically, in its genetic code. von Foerster (1965:388-390)

It is certainly true that the desk calculator, which does the job of von Foerster's monstrous multiplication table, does not learn like an organism does. It incorporates just one recursive procedure which it has "acquired" by the will of a designer. And yet, one must point out that an organism which has inherited its structure from a previous generation is not entirely free to alter it either. The structure that an organism possesses restricts its behavior to

a certain presumably advantageous class. Unlike the behavior of organisms, the desk calculator is also a deterministic device with inputs and outputs unambiguously fixed. But, considering the sizable volume of matter required to store and retrieve information in the form of physical records and the wealth of behaviors that an organism is capable of acquiring, it is not unreasonable to suggest that biological organisms do incorporate much of its knowledge and wisdom about the world structurally, that is, in the form of procedures for generating information about past instances or for responding appropriately to recurrent situations and not in the form of physical records.

The arguments in favor of a structural memory for explaining human behavior are well developed in recent linquistic theory. The speakers of a language are obviously capable of using many more sentences than they could have been exposed to in the past. Language acquisition and language use must therefore be an inductive and generative process respectively. A child learns the rules of grammar from a few instances and its knowledge of the language becomes manifest in the use of recursive procedures for generating proper sentences. It follows that the knowledge about a language that enables a native speaker to participate in linguistic activity cannot be thought of as stored in the form of a list of the sentences to which he had been exposed. Rather, it must be explained in terms of a set of operating procedures that the speaker is structurally capable of using.

Computer programmers are particularly aware of the difference between a memory involving records and a structural memory. In computing some function one is often confronted with the alternative of either storing that function extensively by putting its constitutive values in core storage or developing an algorithm for generating these values when needed. The former

method demands considerable amounts of core memory space but hardly any time for access, the latter requires hardly any core but time for processing. Organisms may not have this option. When someone is given the sequence of numbers 1,2,4,8, he is likely able to continue with 16, 32, 64, etc. not because he had previous exposure to such a sequence but presumably because the first four numbers suggest to him the hypothesis that each number is twice the value of its predecessor. This is nothing but a function for generating all such values from an initial one. Computer programmers would never dream of using a table of values when an algorithm can do the job and psychological experiments have shown over and over again that numbers in which the subject can recognize a generating function, a relationship, or a similarity can be remembered better than those that appear at random. A structural memory seems to be more economical than the one involving records.

How generative procedures relate to the structure of machines and by analogical extension to the structure of organisms and social organizations is well understood in automata theory. The representation of a computer program in terms of a flow chart indicates the order in which the basic operations are to be performed and the diagram of immediate effects of the same program indicates which variable is to be transformed into which other variable, starting from some input and ending at some internal state and output. Both represent a process structurally, the former by depicting the transfer of control from one process to another, the latter by depicting the processes of communication involved. Both point to the design of machines that perform in the way prescribed.

Social organizations too are structurally describable: the charting of material flows from one process to another throughout a company provides some such description just as it is the case with the organizational chart for a military unit, with the communication network among the individuals of a small working group, or with an account of the roles the members of a family assume vis-a-vis

each other. Each imply in different ways the classes of behavior that a business organization, a military unit, a working group or a family is respectively capable of exhibiting. Each gives an account of how such organizations can behave in given environments.

While the structure of a machine is largely the result of a designer's choice, it is widely recognized that the structure of a social organization is not alone a characteristic of its members. Rather, it reflects to a significant degree the organization's interaction with its environment. Organizations grow according to the resources available to them in their respective environments and adjust in response to the threats that such environments impose. What is being acquired are effective procedures for coping with an environment - not with any environment rather with the one that the organization had to face in the past and, by induction may have to face in the future. Structures that allow an organization to take full advantage of the given opportunities and to counter recurrent threats clearly constitute a kind of organizational experience. And when such structures guide, constrain or in any way affect future organizational behavior, they in the technical sense memorize the past properties of an environment structurally. On the organizational level of the family, for example, the way individuals organize themselves to form a coherent family unit is rarely entirely independent of the personality characteristics of its members. But this may also be explained as a means of maximizing their joint economic opportunities and of protecting each other against such disturbances as caused by unemployment, illness or by the psychological disorders of some of its family members. Observable interpersonal communication, the network of influences and of power, the division of labor, etc. then presumably reflect past experiences of this sort and guide joint efforts for coping with similar

problems in the future. Apparent failures in encounters with a family's environment that result in changes of the family structure must be said to add to or to readjust the structural memory that the family possesses.

The increasing organizational sophistication which can be seen in the natural history of any organization that survives in interaction with its environment equals in effect an increase in structural memory - not so much about the environment per se, rather about the way the environment has frustrated or facilitated the achievement of organizational objectives. Complex social organizations are therefore the most obvious embodiments of structural information. Consider how the system of laws and legal procedures has grown in the United States. Each addition or modification can be seen as a response to a perceived threat whether it occurred in the form of a new crime or invention, in the form of an apparent inconsistency, or because the feeling of justice had changed. Consider how a bureaucratic organization grows by adopting more and more rules to cover all possible incidences it is assigned to handle. Or consider the social experiences that a modern army incorporates in its forms of organization: there are organizational traditions that can be traced back to the experiences of Napoleon's hierarchically organized army fighting another hierarchically organized army. The extensive use of technology since World War I has left its marks in the organization of smaller, more specialized and at the same time more autonomous units requiring more sophisticated methods of communication and coordination. Usually, any slight resistance against adjustments to environmental changes may put an organization at a distinct disadvantage which is immediately obvious in the case of war. For example, when a traditional army fights guerrilla forces that are well integrated into the population, as was the case during the American involvement in Vietnam, material superiority helps only little because much of the past information on which such an army

is built has become invalid. Structural changes are then required through which other means of coping with the new situation may become possible. And in the process of organizational adjustments to the changed conditions, past information is incorporated structurally and is projected into the future procedurally.

I might point here to a possible confusion because an army heavily relies on written rules, regulations and instructions much as organizations in government, industry and in education do. However, the crucial difference is that a memory involving records represents information about past events whereas a structural memory represents information of how to collectively cope with environmental features successfully. To evoke computer analogies again, the difference is analogous to the difference between data and a program for manipulating them. The routines of everyday joint living, the conventions in court, the modes of operation in a corporation, the religious rituals and public ceremonies that people engage in when attempting to solve certain problems collectively are all procedures that may or may not be written down. But they do pertain to how individuals relate to each other and if they have survived the selective forces of evolution, they represent some aspects of the environment structurally.

Again one might ask how structurally stored information can be retrieved. Interception does not apply because one is not concerned with transmitted information. Decoding does not apply because the antecedent conditions that find their representation in the structure of an organization are unimportant when compared to their behavioral consequences. The answer is simple: structurally stored information can be retrieved by triggering it: in a computer, the work of an algorithm becomes manifest as soon as the specified conditions for its application are met (energy always assumed available). In society, legal procedures are initiated when someone becomes a suspect and someone else is sufficiently concerned about this possibility.

The application for admission to a university is acted upon as soon as the completed set of forms are received at the right place, etc. In all these cases procedures are invoked that require individuals to organize themselves for the purpose of executing them. Past information in structural memory is retrieved by triggering it by the right conditions.

Triggering structurally memorized information is not to be confused with stimulus-response type reactions. Organizations that possess such a memory are often organizationally rich enough to have options (unlike the desk calculator discussed above). There is the possibility of mutually exclusive triggers competing with each other. There is the possibility of structural ambiguities which may come out in the corruption of legal institutions or in the multiplicity of ways given situations can be handled. Because the execution of procedures involving coordinated activity involves time, there is the possibility that one trigger affects the sensitivity or ability to respond to a succeeding trigger, etc. In spite of this lack of determinacy, I don't think there is any other unambiguous way of retrieving information from structural memory.

It might be important to recognize that the human members of a social organization tend to talk about their mode of interaction, verbalize the relationships that link them with a whole and give thereby clues as to what a structural memory may contain. But, what individuals say need not correspond to what they do when the situation arises. Even in a more formal context, it is true that all laws are put in writing, but not all of them are enforced in fact. Verbal accounts of existing structural memories may therefore not be trusted. It is of course always possible to observe and to describe how individuals, social groups and institutions communicate with each other over time and deduce from this structural description how the whole may behave in a given environment. But the structures that are

observed at any one point in time are also always only those in current use, that is, the ones triggered by the given circumstances and not necessarily the ones effective in the future. This turns the argument back to where I started that triggering is the basic form of information retrieval from structural memory.

One might also raise questions as to how past information can get lost in structural memories. Most obviously, since structural social memory is so intrinsically linked to the existence of social organizations, anything that makes an organization vanish beyond the time of immediate reconstructability is also destructive of its structural memory. But the more prominent forms of information loss are overwriting, variation and drift. Overwriting occurs when new organizational forms replace old ones whether because of changed environmental conditions or because of the adoption of more efficient methods to cope with an unaltered environment. The variation of existing structures may have numerous causes, individual role interpretation and corruption, to mention only two. Here reference to an original structure may be maintained while the actual behavior varies within limits around this "ideal". Drift occurs when the acquired structures are not subject to periodic checks by the environment and become subject to more or less systematic changes towards a balance with the internal characteristics of the organization. Unfortunately I cannot elaborate on these details here.

Let me again summarize what a structural memory entails. In it information from the past is neither represented spacially in the form of an arrangement of marks in a physical medium nor is it represented temporally in the process of continuous transmission. The defining feature of a structural memory is that past information is represented in the organization of interacting parts into a dynamic whole. In comparing a multiplication table with a desk calculator I tried to show that the structure of the latter embodies a behavior (an algorithm) that

enables it to represent generatively all values contained in the former. They are thus isomorphous of each other. One is capable of representing the other without loss however in entirely different ways. The evolutionary advantage of a structural memory over a spacial one is that the former requires much less storage space.

On all levels of social organization, structure, that is, the way its members are related to each other or the communication networks through which individual activities are coordinated and directed, limits how an organization can behave To the extent this structure is explainable as an adaptive response to the opportunities and threats of an organization's past environment,the organization must be said to memorize certain characteristics of the environment structurally and project the fruits of this past interaction with the environment into the future procedurally.

Past information is retrievable from structural memory by triggering it with the appropriate conditions and where it is stored. While there may be other ways of gaining access to structurally stored information, its procedural manifestation is the best indicator of its presence. Numerous properties of structural memories are linked to the way information enters and becomes available when needed.

Search Procedures

Particularly because of the great amount of information that a social memory can contain, relevant information is quite often difficult to find and these difficulties become even larger when the needed information is dispersed widely in time and in space or when special barriers are erected to protect such information from being discovered. I like to consider search procedures as those processes that are employed to locate relevant information in time, in space, and in kind, often against apparently insurmountable odds.

Research and development problems provide the most prototypical examples of situations in which efficient search procedures are decisive in bridging an existing information gap. In order to incorporate into a design as much information as possible, it is quite common that a very large number of reports may have to be read, most being irrelevant in fact. Finding a solution then depends not so much on the retrieval of information rather on the efficiency of the search procedure available. Because research reports tend to be somewhat more standardized (at least clearly distinct and written in the same medium) computers have already provided useful selection aids for literature references. Another problem of search is criminal detection. This may involve identifying one out of thousands of widely dispersed and highly mobile suspects. Among the many clues that may become available during an investigation, most are likely to be unproductive and the successful conclusion of a case presumably depends on following the right clues early enough and without being sidetracked. Related to such situations is the problem which many intelligence departments face when trying to obtain information that someone else deliberately hides or encodes into an unrecognizable cipher. Less extreme though socially probably more significant is the problem of an individual finding his way around in everyday life. Individuals tend to become expecially aware of the problems involved

when they find themselves in a foreign country and only a few of the habitually used routines for getting things done work. These search procedures may be very elementary, such as, how to get information on the use of public transportation, how to find a doctor, how to meet similar minded people, how to avoid getting in conflict with the law of the land, etc. For a foreigner, search procedures become the less successful the less he is familiar with the existing social memory structure.

Perhaps a word on the logical status of search procedures is in place. Retrieval procedures always operate on information, whether they intercept some temporally coded information, whether they decode some physical record or whether they trigger some generative procedure. Search procedures, on the other hand, operate on information about the temporal and spacial location or about the kind of information stored. Thus, search procedures operate on information about information or on meta-information as this is called, This is one of the more important features that distinguishes search procedures from other procedures that might be involved in making past information available.

Another important feature of search procedures is that they tend to be iterative in procedure and heuristic in effect. The iterativeness of search procedures is exemplified in the stepwise work through a classification tree, like that of the Dewey Decimal System. Each step involves the use of meta-information to make a decision among several alternatives the result of which is in turn a guide to another set of alternatives, the decision criterion of relevance remaining the same throughout. The heuristic nature of the process lies in the inevitability of chance in the process. Because relevant information tends to be rare, random sampling is unlikely to be successful. On the other hand, perfect information about the location of needed information makes a search unnecessary. Thus search procedures weld available meta-information into a

guiding principle that increases the probability of finding needed information above that obtainable by chance.

Interesting differences among search procedures emerge as a consequence of the way the meta-information is stored in a memory. Let me exemplify temporally stored meta-information by a technical example: a radio receiver is designed to intercept and to decode messages within a wide range of the radio spectrum. In understanding this, one must distinguish between a carrier wave which is characteristic of a station and corresponds to a reverberating circuit of the receiver and its modulation which represents the information that the radio receiver actually reproduces as sound. The listener who wants to hear a particular program may achieve his aim after making the approximate choices among carrier waves that carry it. Relative to what he wants to hear, the carrier wave is meta-information in temporal code.

More obvious are examples of meta-information in the form of physical records. Telephone books, lists of addresses, bibliographies within a certain domain of knowledge, the signs in front of a shop, the landmarks within a city, etc., all can assume the function of pointing to something else that is needed to know.

Hierarchical social structures which incorporate much of an organization's past interaction with its environment can provide examples of structurally stored meta-information. Generally, higher level employees are less accessable and less often affected by variations in the environment than lower level ones. A minor problem which can be handled by a clerk will hardly trigger high level executive responses. The very labeling of a disturbance as "minor" prevents its communication higher up and is a very rudimentary form of meta-information about the problem and about the procedures that are to be evoked for solving the problem as labeled within the organization. The meta-information is then represented structurally in the communication conventions of the organizations.

In the following I will distinguish between the two most common kinds of search procedures; search by indices and search by association. And I might note there seem to be correspondences to these search procedures in cognition as well as in computation.

Search by indices

In electronic computers, most information is stored in addressed memory locations. A computer program refers to such information by its address and the computer's control unit locates it in memory and transfers it by this address. In the process of obtaining stored information no consideration is given to its content. It is not surprising that computerized information retrieval systems seem very much confined to this principle of representing and locating the information of interest. As discussed in an earlier section of this paper, literature on the subject considers classification and indexing a prerequisite for search to take place effectively and it is evident that the search for information operates not on the substantive information which is the concern of a user, rather, on meta-information in the form of tags, class markers or indices that represent the substantive information internally.

The most apparent outgrowth of such search procedures are hierarchical classification schemes of which the Linnean System of classification in biology and the Dewey Decimal System has already been mentioned. These schemes are in fact hierarchies of indices along which the search proceeds from the most general index to the most specific one until an item of information or a record is located or identified. However, there is no need to conceive this as an abstraction ladder. In the multidimensional representation of a record, searching one dimension at a time has the same effect of a stepwise reduction of the alternatives to be considered. And this is the most obvious characteristic of any search by indices.

In society, much of the knowledge about the world can be regarded as indexed. Consider the famous 20 question game in which one person is allowed 20

questions with yes or no answers to identify an object or an idea that the others have in mind. The game imposes a binary decision tree on the mutual knowledge about the world. And the interaction between the participants exhibits an iterative search procedure working itself down along mutually understood indices.

A city's yellow pages of the telephone directory are organized to search for a business by its index. Looking first for plumbers in the Philadelphia directory may cut down the possible numbers to about 1/100. And if one continues to look in a second step, under West Philadelphia (a form of listing that has been discontinued here), the additional cut down rate may be something like 1/10 so that the number of listings that have to be scanned in the end becomes very manageable. In order to engage in the search for a business telephone number the user has to bring with him a conceptual system of the indices roughly corresponding to the listings of the directory. It must be noted though, that the search procedure that a telephone directory facilitates is still very simple, involving up to two steps only, and is very much intentionally designed for the purpose. The search process involves an interaction between an individual and an artificial device only and is in a sense a technical problem or a psychological one and not social in procedure.

Many search procedures are known to involve interpersonal communication. And a large class of situations in which one individual seeks advice from another can serve as examples of the processes involved. Obtaining advice is usually preceeded by a search for the person which would give the most powerful lead in the sense of minimizing a systematic scanning of people. For example, lawyers

are usually members of the local bar association. If someone encounters a problem which he considers to be a legal one, he may turn first to the bar association which puts him into contact with a suitably specialized lawyer who in turn can provide access to the information needed to solve the client's problem. The procedure followed represents a highly institutionalized search procedure for legal information with the bar providing information about lawyers and lawyers possessing the means of providing information to the user. And this seems to be the typical procedure for searching out advice from any competent institutionally defined specialist who is not consulted on a regular basis.

Even in public places one can observe that certain kinds of people are more frequently asked for directions than others, presumably because they are marked by looking like well informed locals and do not constitute a threat to the ignorant questioner. That search procedures of this kind can involve many search steps can easily be experienced by individuals who find themselves looking for an obscure address in a strange metropolis. Sign systems, direction markers, color coding of paths are all designed to facilitate the search procedures according to which individuals guide themselves to their many possible destinations.

A study of the adoption of a new drug conducted by Coleman, Katz and Menzel (1966) revealed that most doctors turn to other colleagues for advice after they were informed about the drug by the detailman of the drug company. The study did not shed light on whether the advice given concerned more information on the use of the drug which the detailman may have neglected to provide, whether the advice consisted of leads to literature on the drug (which ranked second as a source of advice), or whether the advice merely provided a stamp of approval. However, the fact that the researchers could identify opinion leaders within the community of doctors studied demonstrated that even in relatively non-hierarchical

social structures, the search is by no means random. In fact, some colleges seemed to be indexed with being better informed, with providing more helpful advice than others.

To summarize briefly, searching by indices presupposes that potentially relevant information is in some way represented by various ways of describing the kind it is and/or its location in time and in space. This is so irrespective of the storage medium of the information to be retrieved at a subsequent step. It is these representations of selected aspects of information which a search by indices considers, not the information itself. Complementarily, whoever searches for this information will have to have a conceptual system, ideally in the form of a decision tree, into which information about the kind or about the location of the needed information is successively inserted. Lack of complementarity of indices about information and of decisions during search point to interesting reasons for lack of success in locating relevant information.

Search by Association

The best illustrations of the second kind of search procedure are taken from the kind of psychological experiments which are responsible for the use of the term "association" for cognitive processes: when subjects are presented with a stimulus word and are asked to verbalize what comes immediately to mind, they are likely to respond with words that are either in some way similar to the stimulus, phonetically like in lime - dime or semantically like in car - truck; opposites like in day - night; contingent upon each other like in news - paper; functionally related like in hammer - nail, etc. The catalogue of explanations for such responses is large. The experiments do provide evidence for the fact that at least some portion of the human brain works on the basis of associative chains which may become manifest, in a behavior that goes from one cognitive state to the next according to some previously acquired link or according to some property that makes the states appear alike or comparable. All of these principles of association are reducible to some notion of distance, difference, similarity, proximity, associative strength and the like and to maintain the strength of such links, individuals use a variety of mnemonic devices like repetition and limericks which heavily rely on the nature of the information to be memorized and not on their possible location. Relevant information is thereby thought to become available cognitively, whenever it is associatively connected through a sequence of links with the perceptions at present.

Generally, searching by association seems to presuppose that any two pieces of information are related in such a way that whenever one is found, the other is likely to come up in turn. It is the likelyhood of such a connection which psychologists measure in terms of "the strength of association"

and for which they have developed the above mentioned catalogue of explanations. Looking beyond two pieces of information at a time, association seems to presuppose that information is stored or at least treated as if it were organized as a field which becomes weaker as the distance to the relevant information grows. Searching then becomes very much like a hill climbing along a path of increasing relevance of information, the relevance being determined by the particular need of the searcher.

To return to the social domain, the aforementioned study by Coleman, Katz and Menzel (1966) also noted among the reasons for early adoption of the drug: the sharing of the same office, frequent discussions of medical cases and friendship, including a common social life. It is likely that the information which finally decided the adoption of the drug was then not so much sought at a known location, for example, from a college who is consensually labeled an expert in drug use, rather, the information that was utilized in the process of drug adoption may have become available in association with other communications, that is, this information may have arisen in a professional - social discourse that is favorable for such information to come up. If the findings can be so interpreted, then one would be hard put to identify any indices of the information that was utilized in the end. Rather, the search process must then be said to have been based on some of the features of the needed information itself. It is these features on which judgements of the information's relevance depends. This distinction is crucial in differentiating between a search by indices and a search by association. The former discards the information content during the search, the latter extracts meta information from it.

In society too, there seems to be a catalogue of explanations for the

manifest associative links and their relative strength. For example, doctors who share the same office are also likely to be mutually aware of each other's medical practice. And the practice of one doctor may then be transmitted to the other through unintentional exposure to each other. Searching for information in the social proximity of a piece of information that is similar to the one needed is a common way of proceeding with the search.

It is well known that the increasing reliance on communication technology rates geographical proximity less and less significant in determining the accessability of people and information on the one hand and the efficiency of dispersing information within society on the other. Searching for an original reference, tracing the source of a rumor or, to use a contemporary example, identifying the origin of the authorization to break into Watergate and to destroy records associated with this act heavily relies on the knowledge of who can communicate with whom, who did communicate with whom and what was said. It is a search that involves tracing a sequence of events backwards and assumes that each was communicatively linked to some predessessor irrespective of geographical proximity. A communication network may therefore be said to give another basis for the search by association.

Similarly, criminal detection relies only partly on the indices of suspects including where they had been at the time of the crime and whether they were capable to commit it. Important leads are often obtained through informal contacts with the underworld within which some information about the crime may have spread. One of the assumptions underlying such a search is that crimes may require collaboration which tends to be preceeded by attempts to recruit, they may require equipment and consequently suppliers, or, they may require the dispersion of goods through the

channels of trade. Crimes can rarely be committed entirely without producing some "noise," i.e. whithout causing associated phenomena to occur. When information is so scattered in distribution, the first bit of knowledge, however little this may be, is often the most difficult one to find. But it immediately acts as a pointer to the next so that the search can reveal more and larger quantities of information as search time progresses. Here the field surrounding relevant information is structured by the network of correlated events through which the criminal act is communicated to others.

I began to write this paper during a short visit in a foreign country where I became keenly aware of how much one needs to know to find one's way around in pursuit of everyday social activities: what one normally seeks to buy in an U. S. drugstore can be purchased there only in several specialty stores which are widely dispersed and difficult to seek out. One searches in vain for a beer place because it is delivered to the door by the milkman. While I was relying on the telephone directlory, maps, tourist guides, train and bus schedules and most of all on friends who I tagged as experts in their own culture, I also noticed to rely on another principle of search by association which might be stated like this: to get what you need immitate the behavior of those who are likely in need of the same. By this rule it is not difficult to locate the ticket counter in a railway station, to get information on how fast to drive on roads, where something is going on on Saturday evenings, etc., all without asking a single question. The field surrounding the relevant information is established by immitating the behavior of people with similar aims.

Search by association is also demonstrated by a variety of public behaviors. For example, if a television viewer were to search for the information

he wants by examining the television guide or similar program listings and subsequently, by switching to the right channel at the right time, then he would exhibit the strategy of searching by indices. However people rarely do this. "Channel XX is always exciting," "XXX has the better news," "XXXX stars in this program," are some of the arguments that people employ when either offering themselves to be exposed to or searching for certain kinds of information. The chain of associations that a public thereby exhibits is explainable by a rule that may be stated as follows: information that is in some respect similar to the one that was useful or enjoyable in the past is likely to be useful or enjoyable in the future. Again one sees the idea of a field being judged whose gradient serves as a pointer to the information that is needed. In this case it means more of the same. Why individuals do exhibit information seeking behavior in attending to the mass media has been the focus of a study by Atkins (1973). But how this is accomplished in fact is still a wide open question.

Evidently, success in searching by association depends on the correct interpretation of the meta-information available, in particular, on the correct interpretation of the direction into which available clues point. In biological life I presume most clues are correlationally connected with the wanted information. In society many clues are established by fragile conventions, agreements or coorientations and they require rather different degrees of sophistication. Trying to find a restaurant by going in the direction of an increasing smell of good food is probably the simplest and in a sense purest example of a search by association that utilizes the correlation between odor and food. The reasoning employed in interpreting the meager information about suspected criminals may employ a

complex logic which incorporates knowledge about communication links, about individual motivations, social inhibitions and cognitive capabilities and in addition about technical correlates of criminal acts. I suppose, being sent around in city hall, say, from one office to another without getting anything accomplished would demonstrate either a lack of success in utilizing the meta-information available or a bureaucracy's way of preventing the field surrounding relevant information to be recognized by a citizen. Often though, the search is facilitated by formal organizations, some of which call themselves "associations" which is not entirely accidental, by the social system of classification and stratification, which puts similar people with similar information reportories in the same class so as to be found by association, or by longstanding habits and conventions. In some cases there even exist institutional controls for maintaining the associative links between the items of information stored, presumably to facilitate the search by association. Only to the extent the information comprising such fields is maintained over some time and only to the extent this field is recognized by a searcher can a search by association be successful.

To summarize again, the search by association relies on a meta-information about the location of relevant information which derives from the content of the information being searched, not from the labels that may otherwise be assigned to it. In particular, for the searcher this involves assessments of the relevance of the information at hand and estimates of the direction in which the relevance of the information being searched is likely to increase. On the part of the memory organization, this involves storing information as a net or in the form of a many dimensional continuum.

in which information contents that are more similar are also in closer proximity to each other whereby the notion of "similarly" and "proximity" may have a variety of interpretations such as "related" and "accessability." In the comparison of available information and needed information, pointers towards increasing relevance are obtained through which the stored information obtains the characteristics of a field of varying strengths.

Summary and Prospects

I defined memory as a form of explanation in which the material basis or particular information processes within machines, organisms or within social forms of organizations are taken to account for the observation that information about past events participates in structuring the present and future behavior of a system. In a sense, this is a structural-behavioral form of explanation. From the information retrieval literature I took storage to refer to the material or procedural features that have the effect of maintaining information from the past; retrieval, to refer to the process by which their content is in some way reproduced; and search, to refer to the processes by which relevant information is located within storage.

When examining some social processes in which memory is behaviorally manifest, it seemed that the conceptions which developed in the course of designing mechanical information retrieval devices are too restrictive. In effect they have focussed attention to only one out of at least three different kinds of memory in society. These three kinds of social memory have been discussed above and may be summarized in the following table:

	Storage	Retrieval
Temporal Memory	Temporally coded information is in the process of transmission from one point to another and possibly back to its origin	Interception of the ongoing flow of information at particular locations in time and in space
Memory Involving Records	Spacially coded information is impressed upon a semi-permanent medium which can be manipulated in the form of separate records	Decoding of the encoded information or interpretation of the configurations that the medium bears
Structural Memory	Information is manifest in the organizational structure or in the mode of operation relative to a particular environment	Triggering an "appropriate" response by an organizational form to particular environmental conditions

Furthermore, two kinds of search procedures were distinguished:

	Storage Organization
Search by Indices	A hierarchy of indices representing the location in time and in space or the kind of information searched
Search by Association	A network or field of items of information (content) within which distances are correlated with the accessability of relevant information

The design of mechanical or electronic information retrieval devices (artificial memories) has favoured the storage in the form of records and the search by addresses as indices are called in this field. In society the other memory processes are as important though much less understood in detail.

In suggesting these distinctions, it is not intended that these remain purely academic or entirely verbal even though this may appear so at the current stage of development. In fact most conceptualizations have been formulated with possible computer simulation or mathematical formulations in mind though this must surely await many more detailed analyses of the mechanisms of social memory.

In all these considerations I have deliberately postponed answering questions regarding the scientific relevance of the proposal: why should

one bother with extending the psychological notion of memory and project experiences with the design of information storage and retrieval devices into the social domain. How does this undertaking affect scientific theory or social practice? Let me suggest the contributions such an undertaking can make to social theory and methodology in the social sciences, to the sociology of knowledge (or of information) and to communication theory respectively.

Firstly, much of the theorizing in the social domain has avoided systematic complexities in the time dimension. The reason for this might lie in the fact that interactions are difficult to describe and to analyse. It seems easier either to focus on a small phenomenon and trace its history as far back as possible as most historians do or to describe a complex situation, for example, a social organization, without consideration of the way all of its components evolved. In addition to this state of affairs and in correct recognition that ongoing social events tend to be shaped by "historical forces," there exists the sometimes dogmatically adhered to belief that methodology in the social sciences ought to restrict itself to a historical approach. But when one examines studies of this kind, most of which deal with unique events, one has great difficulties to decide in any vigorous manner whether the past events of the scholar's choice do indeed offer an explanation of a subsequently emerging situation or whether the claim stems from the theoretical committments underlying the research. Hard texts are not available and may never become available unless one examines the corroborating evidence that lies in the mechanisms through which the "historical forces" are channeled and transformed.

I would argue that there is no reason to suppose that past events have

an impact on the present behavior of any system - artificial, biological or social - unless there exists a memory inside or outside the organizational form being studied that maintains the information about these events. If one is considering unique events, as many social scientists do, then there is a need to demonstrate by independent evidence that a memory exists before a historical explanation is accepted. Only when one considers a great number of comparable behaviors may structural considerations be bypassed. A memory with all its peculiar properties limits a systems ability to be responsive to the mysterious"historical forces" which some social scientists rely so freely. They study of the memory characteristics of social processes may therefore be said to relativize the historical approach and will give, where it is indeed appropriate, the social theories that are formulated in those terms a more solid foundation. As I said in the beginning of this paper: "human individuals, social organizations and societies are alike in that their knowledge of past events is to some extent maintained and brought to bear on their behavior." To understand how past events are selectively maintained and forgotten, to understand the relative efforts, required to identify a piece of information or the probability of losing it altogether, and to understand the errors involved in retrieving the content of the information that is put to bear on current behavior may shed light on the future of social forms of organization, how intelligently or informed such forms behave and whether they can cope with the threats of their environment.

Secondly, explanations in terms of social memory may also provide new conceptual tools for the sociology of knowledge. Following Merton's (1957)

exposition, the European Wissenssoziology has focussed attention to primarily three problems of understanding: (a) how social relationships and particular life situations influence individual thought processes, (b) how problems of validity are solved in particular social contexts, and (c) how different types of Weltanschaungen manifest themselves in various social strata (social classes, generations, parties, cliques, etc.). Mass-communication research, particularly in the United States, has added to this list the problem of understanding (d) who, which, and with what effects information and entertainment is disseminated and accepted within society and through which mass communication technologies this is accomplished. The sociology of knowledge is a clear expression of the concern with information and information processing in society but it has limited its focus to individual knowledge and cognitive processes which this paper tried to transcend.

Explanations of historical processes in terms of social memory can shift the emphasis from the individual to the system of interconnections and to the superindividual processes through which information is maintained, searched, retrieved and made effective in influencing the behavior of social forms of organization or of a society as a whole. The thought processes of the individuals involved, their interests, ideological committments and powers are then only part of these phenomena.

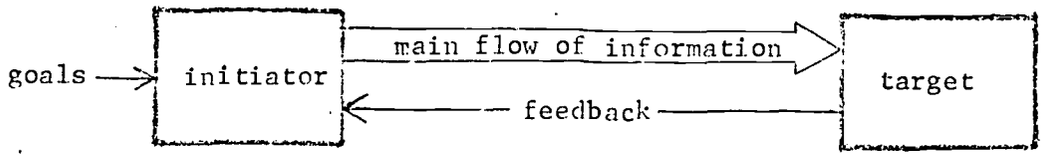
For example, from experiences with the design of information retrieval systems we know of two fundamental limitations which have important epistomological implications: (1) no memory can store information that is incompatible with the nature of its organization. And (2) the only information that can be sought, found and brought to bear in a given situation is that which corresponds in structure and in coding to what the search procedure can "comprehend." As an illustration consider the computer analysis of

answers to open ended questions obtained through a mail survey. In punching hollorith cards, information contained in the handwriting of the respondents, for example, is irretrievably lost for the analysis (unless special notational provisions are made for the purpose). And when it is the aim to analzse a particular concept, say, perceptions of the U.S. presidency, then a search procedure that would identify all sentences that contain the word "president" is likely to locate many irrelevant sentences and omit even more relevant ones precisely because the literal name is not exclusive to the concept under consideration. I am using this illustration not so much to criticize the low level of "comprehension" that a search by words exhibits but rather to show that the limitations on information processing are real and that the losses are the necessary consequences of the process involved.

The mode of storing information in society is similarly restrictive of the information that is being maintained. Ideological committments and even the so-called value-free theoretical orientations in science which provides the terms in which observations are cast will implicitly determine which information can be processed and stored and which will be ignored as inconsistent with the frame of reference provided. The problem is not to immediately judge these frames evaluatively, rather then to ascertain the consequences they will have for future decision making and behavior. We also know of the great differences in efforts to obtain different types of information. Some information is so abundantly available and to everyone, that one has difficulties ignoring it while the search for other information may incur high costs to the one who needs it. Such differences will no doubt affect the speed, scope and the direction in which a society

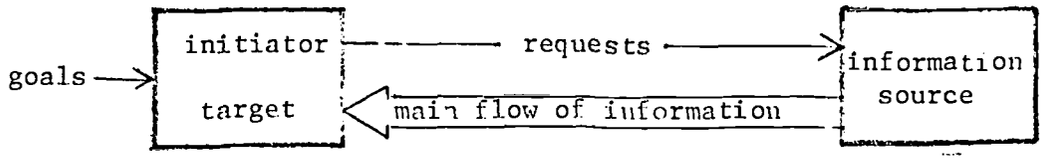
or any of its organizational forms develop. Social organizations may protect their memories from being accessed by others which adds the aspect of intentionality and of control to the social processes that thrive on such information etc. In concluding the discussion of this second contribution, I wish to state is that the concept of social memory can integrate some of these apparently unrelated phenomena and provide structural-behavioral theories of information handling in society which I would take the sociology of knowledge has attempted without the advantage of such conceptual tools.

Finally, the elaboration of social memory conceptions may help to modify an unfortunate orientation in human communication theory. It is fair to say that most human communications theories have been concerned with sender initiated communications. This may stem from the early preoccupation with propaganda and with mass communication which are essentially one way process with a sender supplying the information that the receiver is expected to consume. This orientation is evident even in situations in which two way communication is possible in principle. Diffusion research is a case in point. It is committed to the study of how a change agent who is in the possession of superior tech ology can change the attitudes and behaviors of peasants who should be induced to use such technology. The very notion of "communicative success" which is manifest in the equation of "communication failure" with "the inability to get a desired point across" points in the same direction. In theory, the initiator of the communication needs not to listen except perhaps for the thin feedback indicating failure or success. Graphically, sender initiated communication may be depicted as follows:



It might be noted that this scheme when put into practice favours the development of authoritarian relationships. Much of our educational process is set up that way: the teacher decides on the topics to be presented in class and the student is expected to absorb and to conform. Examinations provide the feedback information about how "well" the student has performed.

The interest in information retrieval processes forces the communication researcher at least to consider another communication paradigm in which the dominant direction is turned around. I call this receiver initiated communication. Here the emphasis is not placed on a sender's attempt to induce changes in the receiver, rather than on the receiver's active search for information that would improve his own position or facilitate self modification. It begins with the communications about needed information or with a request to an information source which then returns the information wanted. Diagramatically this would amount to the following.



It differs from sender initiated communication among other things in whether the target is allowed to have its own goals and the source have none and it is based on the crucial order in which meta-information and information is considered. In sender initiated communication the information about the effects succeeds the transmission of information. In receiver initiated communication the information about the information needs preceeds the transmission of information relative to the information that is transmitted in either case, both the feedback about effects and the requests for information are meta-communicative in character.

I need not elaborate the fact that much of the communication in scientific research activites can only be understood as receiver initiated. The development of modern communication technologies goes in this direction, for example, communication using community cable television has at least a higher potential of being receiver initiated than the traditional mass media have been. And reforms in education whether through the use of individually operated teaching machines or through social reforms have had the effect of weakening the authoritarian teacher-student relationship by making the teacher more into something like a consultant or a resource person who facilitates a self directed process of student learning. Perhaps one spin off of the concern with social memory is that such communication processes may become theoretically tractable and the consequent liberalization may indeed be speeded up.