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INFORMATION OVERLOAD: PEACE OR WAR WITH THE COMPUTER

LESLIE T. WILKINS*

Will intelligent computers ever be able to make better decisions than judges, parole boards, probation officers and others concerned with the offender? Can the provision of information by rapid retrieval systems connected to large-scale computers or information machines assist the courts? Should we look for the take-over of the human decision activities by automatic processes, or for some form of cooperation between the human decision-maker and the computer? Will computers cooperate? Will decision-makers cooperate?

The obvious answer is that human intelligence will always have an essential part to play in decision-making, no matter to what extent computers can be designed to facilitate the processes of information retrieval and analysis. Currently many criminal justice procedures and decisions could be assisted by the further utilization of computers, but, in order to cooperate, both the decision-makers and the computers must learn to communicate. Computers can certainly be programmed to learn, but they must learn from somebody. Considerable problems exist in organizing materials so that optimal use can be made of the computer and the particular strengths of human intelligence.¹

This paper is divided into three parts. The first section considers certain general issues and some questions which are somewhat abstract if not "philosophical." Often the relevance of specific issues can only be discovered by taking an abstract viewpoint. The second part reports in summary form a number of recently conducted experiments relating to parole and probation. Apparatus which simulates the operations possible on an up-to-date computer is used to examine the interaction between the decision-maker and the

machine. Finally an attempt is made to draw together the experimental evidence and the moral and philosophical questions while focusing on the present state of knowledge and process, and to suggest means of improvement.

MORE INFORMATION OR LESS?

Most decision-makers believe that if they are given sufficient and correct facts they can make the decision required of them. Many believe that if their decision is somehow proved to be incorrect, the information was insufficient or inaccurate. Seldom does the thought occur that the decision might have been a poor one because there was too much information for human intelligence to cope with. The decision-making machinery within the human skull can be overloaded just as any other piece of machinery, and when it is overloaded it fails to function as well as it might. A car indicates by groans and wheezes when it is overloaded, but no indicator seems to exist which advises the human intelligence that it is attempting to handle too much information at once. Only under experimental conditions can it be shown that the human intellect, no matter how intelligent the individual, can process only very small quantities of information.

Computer salesmen, not unexpectedly, fail to stress these findings when attempting to sell equipment. Speed and quantity of information retrieval are their watchwords. But rapid retrieval may or may not be an asset of any information system. Whatever goes into the computer has to be put there, and whatever comes out has to be interpreted by the human decision-maker. The computer can tell neither whether a decision is correct nor whether it is morally acceptable. We may define "correctness" in terms of certain operations which the computer can carry out, but it is humans determining the logic who decide whether a computer-made decision is "correct" (consistent) or incorrect.

KINDS OF DECISIONS

We have difficulty discussing issues of this kind because our language is extremely imprecise.

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¹ This is by no means a new idea. The possibility of cooperation between man and computer in relation to decision-making has been discussed for more than a decade. See, e.g., I.R.E. TRANSACTIONS ON HUMAN FACTORS IN ELECTRONICS: H.F.E. 2 (1961); Yntema & Torgerson, *Man-Computer Coordination in Decisions Requiring Common Sense*, in DECISION MAKING, 20-26 (W. Edwards & A. Tversky, ed. 1967).

It is impossible, even with the most appropriate choice of words, to express any complex concept in such a way as to avoid the danger of ambiguity. We talk about decisions and decision processes as though all decisions were similar—a decision is a decision. But consider just two examples of decisions: the first, the President decides to go to war; the second, I decide to wear a pink shirt. Clearly these are two very different “things.” But different as the “things” are, we use the word *decision* to cover both instances. If we use the same word, we must infer that there is some sense in which the “thing” is the same. If the “thing” were totally different, surely a different word would have been used.

Anthropologists tell us that people who live in the Arctic have many different words which we would translate as “snow.” They have these different words because it is necessary for them to discriminate large flake snow from small powder, and so on. In their experience the various qualities of “snow” are so different that their language has evolved different words. In our language of decisions we have not found it necessary to discriminate decisions with serious consequences from decisions with trivial consequences in terms of the noun which describes the activity we call the “decision.”

Is it possible to assume that the processes of “coming to a decision” are sufficiently similar whether the decision relates to trivial or extremely serious matters? Is the difference in the two “decisions” merely a matter of degree or magnitude? Can we assume that any knowledge of the process relating to the one kind of decision can be applied to the other? Before we can consider these important questions we must break down the “decision” process into some more useful categories of operations.²

IS DECISION-MAKING A PROCESS?

We have many words by which we refer to the idea of a decision. We talk about “coming to” a decision, using the analogy of a journey. There are other such descriptive words: we may “cut off discussion” and “force a decision;” we may “weigh the evidence;” we may “make” (the analogy of build-

² The ideas of utility, probability, and risky or riskless decisions, which have been developed in the field of decision research, do not help very much at this point. The consequences for the *decision-maker* of the President's decision to go to war may be less than the wearing of a pink shirt by a job applicant, and it is not very meaningful to ask whether the President would prefer to go to war or to wear a pink shirt!

ing or constructing) a decision; and so on. Some of the terms we use suggest that “making a decision” is itself a process, while other terms suggest that the making of a decision is not a process at all, but rather the termination of a prior process of information search, retrieval and analysis; we say we have “decided” when we no longer wish to seek for more information. It is odd that our language is so imprecise in describing such an important process. We have a very poor collection of analogues or metaphors to describe the decision act or process or termination of a process, and we do not discriminate, by the term “decision,” the very different classes of the act.

Despite the lack of precision in our language we generally assume that “information” is related to “decision.” Perhaps our language is not much better at describing what constitutes “information,” but it is possible to utilize the operational definitions of Shannon and others³ where necessary. Other concepts are closely related to the idea of “decision.” We must examine some of these before we can settle more precisely upon a description of a “decision,” and consider cooperation with the computer in the “decision” situation. However, let us first take the idea of information. We generally assume that a quantity of information exists, in our minds or elsewhere, which is relevant to the decision we are to make. This information may be formally stored in records, or we may make direct observations (*e.g.*, the color of the shirt) and think about possible situations (*e.g.*, meetings we may attend that day). We have a strategy of search for the information; we may call for the files or merely stop and think (recall and make projections). Having obtained the information, or while obtaining it, we will begin to “process” it, relating one item to another and attaching certain significance to each.

No one would assume that similar kinds of information were of common utility in the case of the decision to go to war and in the case of the pink shirt. But this does not imply that the “strategy of search” for information used in the two cases might not be similar, nor does it follow that the methods whereby the different kinds and qualities of information are processed by human intelligence are dissimilar. Do we “search for facts” (what are “facts”?) in exactly the same ways whatever the nature of the decision to be made? Is the idea of the seriousness of a decision

³ See, *e.g.*, C. SHANNON & W. WEAVER, *THE MATHEMATICAL THEORY OF COMMUNICATION* (1949).

a different consideration from the idea of the decision? If we are to discuss the "seriousness" of a decision, it is obvious that we shall need information as to the likely consequences of the decision. But is this not absurd? If we know only the consequences of making the decision, we still have no information by which to discuss its consequences or its seriousness since we have to assume that the consequences of deciding something different or even deciding-not-to-decide may be either more or less serious. Thus the idea of the seriousness of the consequences of a decision implies some alternatives are possible and that these can be compared.

Leaving aside the idea of the seriousness or triviality of some decisions, we may note a further related consideration in the decision process or act. We may say that we are quite confident that a decision is correct, or we may lack confidence in a decision. In some cases we may be prepared to make a "decision" even though our level of confidence is low, while in other cases we would make strong efforts to increase our level of confidence before "deciding." It is reasonable to suppose that for those decisions which we regard as trivial (e.g., the pink shirt case), we would be prepared to act at a low level of confidence, whereas in more serious cases we would want a much higher degree of assurance before "deciding." Thus it appears that there is a relationship between the degree of confidence we require in a decision and our assessment of the consequences of the decision. We require higher degrees of assurance where large differences in alternative outcomes rest upon our decisions. Thus we arrive at the issue of probable outcomes, where the emphasis is on the term "probable." The idea of probability and the idea of degrees of assurance or confidence may be taken as an identity.⁴ Thus we may relate the perceived distance between alternative probable outcomes to the degree of confidence required before making a decision.

If the decision-maker wishes to increase the level of confidence he may do more-of-the-same or perhaps he might try something different. In either event it seems reasonable to assume that to increase a level of confidence more work will

be required in some form. It is unlikely that less activity on the part of the decision-maker would result in a feeling of greater confidence. It makes sense to view the "decision" as a termination of a process of information search. We cannot reasonably argue that a person has reached a decision if that person persists in seeking further information with regard to the act he must make or fail to make. It is, of course, possible to terminate the search for information while the level of confidence in the "decision" is still low, but the degree of confidence is a quality of a different order from the "decision." Unless I am particularly fastidious, the decision to wear a pink shirt or not may be one where I do not require much information because I am satisfied with a low level of confidence in the "decision." I may be satisfied with a low level of confidence because I cannot ascribe any serious consequences to making the wrong decision. However, there are circumstances where a person who is not fastidious with regard to dress may require a higher level of confidence in a decision regarding dress; for example, when going for an important interview. The level of confidence required is, in the first instance, related to the qualities of or in the decision-maker, and in the second case, related to the projected likely consequences of his act within the external situation.

The preceding analysis does not throw any light on the processes of information search themselves. In order to increase our level of confidence we may do more of the same. If, however, we assert that the process of information search adopted in the trivial case must be different from that of the serious case, then the question arises as to how many different strategies of search the human intelligence can apply and what determines the adoption of one rather than the other? As the old cooking recipes might say, first catch your varieties of strategies: Whether there is one strategy or many for information search, there is still the further problem of the nature of information processing within the human intellect. Are there different forms of "information processing" which we adopt depending upon either the seriousness of the decision or the strategy of information search or both? How does human intelligence utilize the information it collects and manage to distil it into a decision? What is the process of distillation? Does it closely follow procedures which we can simulate by computer or formalize in other ways?

⁴ In everyday language persons often say, "I believe that . . ." meaning "I think it is probable that . . ." However, a more formal association between "degrees of belief" and probability is discussed in many texts on theoretical statistics. See, e.g., I. GOOD, *PROBABILITY AND THE WEIGHING OF EVIDENCE* (1950).

DECISIONS ABOUT THINGS AND PERSONS

In the judicial process there are many decision branching points. Few of these decisions are trivial. At each point where a decision is required information is available to the decision-maker in a stored form. Often persons in the legal or correctional fields discuss "making decisions about individuals." Actually, a decision cannot be made about an individual, but only about *information* concerning that individual. The individual is moved into one channel or another according to the nature of the decision, but the decision-maker cannot deal with more of the individual's characteristics than he can ascertain by whatever means are available to him. What happens to an individual is determined not by his individual characteristics, but rather by the characteristics of the information sought about him and processed in the mind of the decision-maker. This may seem obvious, but the consequences of this obvious situation are seldom recognized. We often claim that offenders are dealt with in terms of their individual needs, that each person is unique and must be so considered in sentencing procedures, or that there is a necessity on the part of the decision-maker to consider the whole of the information about the offender. These statements are not consistent with the earlier statement which was said to be "obvious." How can any unique event guide decisions when we emphasize its uniqueness?⁵ A unique event may guide our decisions if we are prepared to examine the similarities between that event and others. If we continue accumulating data before making a decision, we shall not reach a decision; hence we cannot obtain "all" the information.

Decisions are made by reference to information that is considered relevant, and the individual who is seen as unique is seen also as similar to other unique individuals. Accordingly, persons are dealt with in terms of the information which the decision-maker thinks is relevant and in terms of the similarities between individuals and not in terms of "all" the information, nor in terms of "uniqueness." The process by which decision-makers seek out information which they consider relevant is important in assessing their decisions.

⁵ For a more extended discussion of the problem of uniqueness as it applies to decisions about offenders, see Wilkens, *Problems in Prediction Methods: The Unique Individual*, in *The Sociology of Crime and Delinquency* (M. Wolfgang ed. 1962).

The means whereby decision-makers process that information into similarities and differences is equally important.

The statement, "each individual is unique," may be useful as a moral statement in the form, "every individual should be treated as a unique person"—individuality should be respected. By extensions, statements of this order can be related to some of the basic concepts in the quality of life we often refer to as "freedom." However, the statement that each individual is unique may better serve to indicate the limitations of our knowledge and the restrictions on our decision-making power, rather than as a basis for the dispensation of justice. The idea of justice is another moral concept related to the idea of fairness. While the idea of justice seems to refer to some external standard, the idea of fairness is essentially a comparative assessment. This suggests a dilemma: we should proceed as though each individual were unique, and yet we should be "fair." However, we cannot know what is fair unless we are prepared to compare one individual with another and to discuss similarities rather than differences. Perhaps it is possible to approach the judicial decision-making problems from the phenomenological existentialist reference and avoid some of these difficulties which may pertain more to words than to processes.

SOME EXPERIMENTAL RESULTS

It is impossible to watch the process whereby a person recalls his past experiences and uses these in making up his mind. It is possible, however, to study the decision process when the relevant information is retrieved from a storehouse outside the individual. There are many decisions which fall within the second class. Perhaps the more important decisions we make are those in which information is sought by reference to external records or other external sources. We may decide which shirt to wear without asking for advice, without statistical data as to the frequency of the wearing of pink shirts, or even without the second opinion of a wife. But we will tend to search for data about yields before investing our money, we will consider a few different vacancies before accepting a particular job or we will refer to newspapers before voting in an election. Judicial decisions are usually related to documents and to written sources of information.

There are very sound reasons for studying the

judicial decision processes at this time.⁶ It has been projected that the use of conventional files will shortly be replaced by more efficient means. Some claim that computer storage and retrieval systems could now replace and improve upon all conventional filing, storage, and retrieval systems. An investigation of the possible consequences of changing from files to computer retrieved parole information display on a cathode ray tube was undertaken. Decision-makers in the parole and related processes are well accustomed to searching through case papers for information which they consider relevant to their decisions. Often the material found in the files is checked or supplemented by information obtained by interviewing the petitioner.

It is possible to simulate the computer of the future by the use of random-access slide projection equipment. This equipment can deal with only a few cases, whereas a computer file would store many thousands of records. Also, the slide projector is much slower in the recovery of any item of information. Nonetheless, the decision-maker may sit at a small console and call up information at will which is displayed a second or two later on a screen. The fully computerized system would have access to any file and any item of information in micro-seconds. Normally, however, one decision is made about one case at any one time, and the limitations of the slide projector in recovering information only in respect of the case which is loaded is not a serious mis-match with the projected computerized system. Using such apparatus, it has been possible to ascertain certain preferences which decision-makers have regarding the displays of case materials and the kinds of decisions they are likely to make under different conditions of display.⁷

Decision-makers differ not only in the decisions they make, but also in the methods they use for seeking information relating to their decisions. For example, persons who are inclined to parole

⁶ The research discussed in this section is reported in full in the sets of research reports prepared for the Law Enforcement Assistance Administration funded Parole Decision-making Project in which the Federal Parole Board of the United States and the National Council on Crime and Delinquency were involved with the writer as co-director. Sets of the reports may be obtained on request to the Research Center, National Council on Crime and Delinquency, Davis, California.

⁷ In the first experiments, decisions were made after reference to cards. A pilot study concerning probation decisions is reported in: L. WILKINS, *SOCIAL DEVIANCE* 294 (1959).

petitioners are likely to select different kinds of information than those who are more inclined to deny parole. In experimental conditions, decision-makers seem to prefer considerable redundancy in the statements presented to them. Where the information was presented in the form of correct English sentence construction (e.g., this person is 23 years of age), decision-makers were more satisfied with the material than where the same information was presented without the redundancy of ordinary English construction (e.g., Age 23). Furthermore, where the information was presented in the shorter form, decision-makers tended to deny parole to the petitioner more frequently. These data derive from simulated parole decision-making conditions, but there seems to be little doubt that the same kind of results would apply in actual cases. It is possible that part of the difference in the decision preference is due to parole boards' greater familiarity with the narrative style of report than with coded data. Thus, one might suggest that if the shorter form of coded data were presented for any period of time, a learning curve might derive which would tend towards reduction of the differences in the kinds of decisions under the two conditions. Unfortunately, this seems unlikely. Similar tests were made where the decision-makers were persons very familiar with coded information and similar differences in decision outcomes by method of codification were noted.

Experiments with groups have revealed very little agreement as to which items in a case file are most useful to consider first when there is pressure to make a decision as soon as possible. Members of the experimental groups are asked to vote for the information they would require. The first item to be called up on the screen (file) may attract between one-quarter and one-third of the persons present to vote to see it. The second item reveals less agreement, and progressively fewer and fewer persons agree as the number of items increases. After the first three or four items have been selected by a group, hardly better than random frequencies can be attached to any of the remaining items in a total file of just over 50 items. However, if members of a group vote for the information they require and the four items most often chosen are displayed,⁸ decision-makers

⁸ It will be noted that it is unlikely that any one member of the group will obtain exactly the four items which he personally desired.

have no difficulty in making an interim decision whether or not to parole the petitioner. On the basis of the four items presented, it is then possible to divide the decision-makers into two groups: those who decided to grant parole, and those who decided against parole. The two groups may then be asked to vote separately for the next four items of information which they would want to see displayed on any computerized file. In such experiments little overlap has been found between the items selected to be seen by the two different groups. Persons who do select items also selected by the other group are very likely to change their decision regarding parole at the next opportunity.

In a majority of the experiments subjects have been asked to rate both their confidence in the decision when initially made (after four items) and at each change thereafter. They have also been asked to assess the difficulty of the decision-making task at each point in the sequence. In light of the theoretical discussion posed earlier the results are extremely interesting. We postulated that the level of confidence a decision-maker would require depends upon the consequences he assessed for the decision—the more serious the probable consequences, the higher the level of confidence required. Furthermore, we thought that a low level of confidence might be easily achieved by examining only a few items of information, whereas a higher level of confidence would require more activity and the processing of more information, and hence could be said to be the more difficult decision. All of the subjects in the entire series of experiments to date, consisting of parole board members, students in elementary statistical classes, graduate students in research methods and criminology, and others, provide ratings which express the completely inverse relationship between confidence and difficulty. As expected, they claim that their confidence in the decision they make increases as the amount of information they have seen increases. Although free to select as much information as they desire, decision-makers do not claim that the more information they see the more difficult the decision becomes; instead they claim that it becomes easier in a direct relationship to their assessment of their confidence.⁹ By stating that a decision in which they are confident is "easy" to reach they seem to be saying that a decision in which they have confidence is one with which they are

at ease; relating the subjective feeling of being "at ease" to the subjective rating of "easiness" as the opposite pole to "difficulty." The individual decision-maker is not aware of the fact that he is performing much more work as he attempts to process more and more information. Rather he believes, without exception, that the processing of more and more information makes decision-making easier. If one were to simulate the human decision-making process on a computer, the greater the level of confidence required, the harder the computer would have to work. We might reasonably say that the computer would find this more difficult.

SOME INFERENCES FROM EXPERIMENTS

The experiments with the simulated computer of the future have shown that different decision-makers, given the facilities of an immediate-access on-line information retrieval system geared to individual case material, would use the facility in very different ways. It is also clear that the method of presentation of the information (design of the software of such systems) could have a considerable impact upon the nature and style of decision-making. Almost any item in a case file is likely to be requested in almost any sequence and at any point in the decision-making process by different decision-makers. Even if constraints are imposed, so that all decision-makers see the same information about the same case in exactly the same form, different decisions will be given. Moreover, despite the very different strategies for information search and retrieval utilized by different decision-makers, these different approaches can result in the same conclusions. Different routes can lead to the same end, and the same route can lead to different ends.

ARE DECISION-MAKERS AS GOOD AS THEY THINK THEY ARE?

The decision-makers' claim that they find the processing of much data to be easier than the processing of little is one of the most disturbing findings. There may, however, be some general relationship between the human performance of any task and the assessment of its ease or difficulty, and subjective feelings of how well the task is done. It is well known that persons who drive after an intake of alcohol feel that they are driving better than they usually do. We are aware of doing badly on a particular task when the situation,

⁹ See, e.g., L. WILKINS, *supra*, note 7.

material, or information becomes disorganized,¹⁰ but so long as a state of organization remains, there may be little relationship between actual performance and the subjective evaluation of the performance by the individual performer. Feedback which conveys the message that the performer is "not doing well" is necessary, in some form, before the performer will acknowledge this as a fact. Thus, it seems likely that we may assess our performance as "improving" the more work we are doing (otherwise we would be unlikely to invest the further effort), and we will continue to believe in this improvement until we obtain feedback by information that the effort is not paying off. There are interesting and important problems with the decision-making process which are not directly related to the quantity or quality of information, but rather to the subjective processing of the data. The processing may be expected to differ according to the different forms of retrieval (e.g. sequence) and styles of presentation (e.g. degree of codification).

An important question was raised at the outset of this article. How much information can be presented to the decision-maker without overloading him and deteriorating his performance in the decision-making process? It seems from the results of the experiments that it might be better not to use the term "process" to cover the decision-maker's search for and interpretation of information, since we may see the "decision" as the termination of the information procurement and processing operation. If this form of explanation is preferred, it seems that the termination of a process is also a process, but of a different order than that terminated. The decision to seek no further information is a decision about information, not a decision about the subject to which the information relates.¹¹ Thus, I may terminate

¹⁰ The perception of organization and disorganization is another intriguing issue of persons and situations which cannot now be developed.

¹¹ The argument at this point is closely related to the well-known "paradox of the liar," believed to have been devised by Eubulides about 350 B.C. For example, if I say, "What I am now saying is a lie" can I be said to be speaking truly or falsely? If I say the statement is true, then as it states, it is false; if I say that it is false, then, as it states, it is true. There are, of course, many statements of this kind, such as "What this sentence says cannot be proved." All these classes of statements cannot be proved or disproved *within the limits of the language* in which each is stated. K. POPPER, *THE OPEN SOCIETY* (1963), discusses this paradox and relates it to similar problems such as that of the paradox of freedom and the paradoxes of sovereignty.

the process of information search when I conclude that no further useful information will be obtained, or I may decide to make an interim decision, or decide not to decide. A decision to make an interim decision is a decision of low confidence in the subject of the decision, but a decision of higher confidence in the need for more information. It follows that information which will lead me to a satisfactory conclusion whether it is worth-while to seek more information is information relating to information, and not information relating to the subject matter.

The problem of reconciling the subjective assessments of "ease/difficulty" and "confidence" make sense if this interpretation of the decision-making operation is used. Decision-makers found it easier to "make a decision" (i.e., to seek no further information) when they had already referred to a fairly large number of items. Decision-making (or information search and analysis) is a process which becomes easier to stop when a respectable amount of work has been done, and which is difficult to stop when only a few items have been seen. Although this explanation makes sense of the rating of subjects in the decision-making experiments, it does not help us to regard human decision-making as a more rational process. If we accept the idea of a decision as the stopping of a process, then it seems reasonable to ask about the stopping rules, and to relate the stopping procedures to the search procedures, since persons "stop" with very different accumulations of information and acquire it in very different sequences. Furthermore, it seems improbable that in the information search strategies of most decision-makers there is any conscious effort to collect information about information as well as about the subject of the decision. More experimentation is required to throw light on these kinds of problems. The importance of information about information will be quickly apparent to one who is familiar with any forms of statistical multivariate analysis. The problem of the overlap of information is well-recognized and dealt with in various kinds of statistical solutions. However, it seems unlikely that human information processing considers the correlations between items of information, and correlated rather than uncorrelated items may be preferred.

Experiments have shown that the sequence in which information is presented to decision-makers, as well as the form of its presentation, is

likely to influence the decisions, irrespective of the content of the information. It has been shown that probation officer decision-makers will continue to examine items of information well beyond the point at which it is possible to remember them or utilize them in a decision.¹² It seems that where the option is open, decision-makers will continue to examine information until they reach a point where they perceive that their organization of the material has broken down—that is, the first point at which there is feed-back to the performer that his functioning has deteriorated.

Where individuals are permitted to seek any information they wish, in any order they wish, and to continue as long as they wish, some persons will change their decisions after a large number of items have been examined. However, although many cases have been studied, no person has yet

¹² It is possible for the average person to remember only some seven or eight numbers which may be dictated to him. However, if a process, such as addition or subtraction is specified, he can continue to process numbers according to the rules of combination well beyond the number of items he can remember. The rules of addition or subtraction are methods for disposing of information as it arrives in a sequential form. If information is processed according to some sequential process or another, then clearly much information can be processed; however, it can only be processed if a rule is stated which enables the sequential disposal of the information to be put into effect. Thus it seems important to know the "rules" of procedure which decision-makers use in the processing of information by means of their own mental faculties. It may be that in addition to some sequential processes for disposal of information the human intelligence can turn items into patterns and deal with materials in that form. Thus we may be able to sum a series of numbers and remember at each stage only the cumulative sum to that point. Many persons will remember playing with typewriter characters to form patterns by superimposition of characters such as: (, /, *, —, and will know that a line of these superimposed forms looks like a row of soldiers, and may be remembered as such. When it may be required to recall the characters we might work out the items from the remembered pattern. However, in the superimposition rule we have lost the sequence information. Rules which enable the recapture or use of more than a few items of information, while facilitating recall, in some regards results in a loss of some information; the kind of loss is related to the kind of rule. Thus, in the examples, the rule of addition results in the loss of items as individual digits, their sequence and frequency; the rule of superimposition to achieve pattern results in the loss of sequence.

stopped the search and settled for a decision at any later time which was different from that decided before the eighth item of information.

It is apparent that decision-makers who believe that they can consider all the relevant information are deceiving themselves. It is also clear that computer salesmen who try to persuade managers that "if only they could have the information at their finger-tips their problems would be solved," have too simplistic an idea of information search and utilization in decision-making. Much is unknown regarding the relationship between the human user and the computer. Computer information systems present us with a new set of problems in man-machine relationships, and these relationships are of a different order from prior man-machine relationships.

TAIL PIECE

As the visitor enters Cranfield Aeronautical College he may see a large mural. It shows a vaguely human-looking beast operating a center lathe; one arm is longer than the other, the trunk and legs are of extraordinary proportions, and the impression is of a humanesque monster of grotesque physique. The caption under the drawing states that for many years members of the College had tried to persuade the manufacturer of center lathes to design a lathe suitable for human operation, but having become disillusioned had taken up a different project—designing an operator for the machine. Are we going to have as much trouble with the design of machines which assist us in our logical functions as we have had, and still have, in the design of machinery to assist in our physical operations? Man may more readily adapt his mind to the "information" machines than his body to the "physical" machines. There is no danger of "the machines taking over", but there are dangers from machine designers exerting much more influence than even they themselves are aware of.

Buyers beware. To beware, be informed. To be informed, investigate. To investigate, invest in and become involved in research.