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PSYCHOLOGICAL FACTORS AT THE MAN-MACHINE INTERFACE

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A Report

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I SUMMARY

Modern life has been marked by the increasing penetration of computers into many of its aspects. This has now reached the point at which the man in the street may shortly find himself interacting with computers, primarily through remote terminal devices. Already, in fact, surprisingly large segments of the population experience the man-machine interface in their daily working lives. Shortly, the same may be true of day-to-day home life. Experience has shown that technological advances interact with human society and actually change its organization. Consequently, it is important that adequate attention be paid to the psychological variables affecting the human user. It seems appropriate that good understanding be obtained of how people feel about the interface, how it can be structured to make it maximally useful and minimally unpleasant for human users, and so on. To date, however, the primary thrust of research into the man-machine interface has been directed towards improving its engineering features. There is inherent in this one-sided attack on the issue, a danger, that, rather than modifying computer functioning to suit people, there will be increasing pressure to modify human functioning to suit computers!

To summarize in very general terms, there are two broad areas in which the psychology of the man-machine interface can be studied. The first of these concerns the on-going states and traits which the human user brings to the situation. The second concerns the properties of the interface design upon which the first set of variables impinges. The ultimate human reaction to the interface represents an interaction

between these two classes of variables. A number of personality factors look to be involved in human reactions and several of these are discussed. It should be born in mind, however, that the psychology of the man-machine interface as it currently exists, may change rapidly in the next few years, with the emergence of a generation of adults who have been surrounded throughout their entire lives by technological devices. It is also possible that there will be no single set of statements concerning the optimal organization of the interface, but that it will differ from area to area in which computers are utilized, and from user to user.

II INTRODUCTION

Technology and life

A major historical development of recent years has been the rapid growth of technology. The point, in fact, has now been reached at which some writers have described modern life as involving "an exploding technology" (Martin, & Norman, 1970, p. 3). It is customary to regard this advance of technology as primarily a blessing. However, it is clear from recent history that technological advances do not usually result simply in the availability of a new comfort or convenience. In fact, as Reich (1970, p. 3) has pointed out, advancing technology changes life more profoundly than simply adding to the machines which are available. Consider, for example, the profound re-organization of social life which has resulted from the mass availability of the telephone or the T.V. or the automobile. One wonders, at this time, how our grandparents ever succeeded in forming social relationships in the absence of those devices! In fact, technology "demands of man a new mind" (Reich, 1970, p. 3).

The problem posed by this developing technology's potential for profound psychological effects on its users has recently been recognized quite explicitly by some writers. Although he was speaking of mass communications, and not commenting specifically upon problems of technology, the remakrs of Weiss (1971, p. 390) are particularly pertinent to the present discussion. In his view, information-technology is now so advanced, from the technical point of view, that the real issues in the area are "economical, legal, and socio-

political", rather than technological. As he put it elsewhere in the same paper (1971, p. 312), the present need is for "psychological and motivational" studies. Other writers too (e.g. Greenberg & Kumata, 1968) have pointed out that essentially psychological variables are now the issues of greatest interest in, for example, study of the mass media.

The emergence of the computer

Precisely this same pattern of burgeoning growth has, in fact, been seen in the area of communication-science. Its growth, from the earliest information-processing technology of, say, ancient Chinese paper and ink, through the first appearance of the earliest "calculating engine" and so on to the development of the most recent devices, has been one of technological advancement (Schramm, 1960). The pinnacle of this growth process, as it exists today, is the present-day computer. Less than thirty years ago, as Martin and Norman (1970, p. 9) have pointed out, the computer was considered to be a theoretical possibility but a practical impossibility because, for example, of the supposed impossibility of building logic circuits based on thermionic vacuum tubes whose life expectancy was so short that a tube could be expected to fail at time intervals shorter than the time required for repair of previous tube failures. However, twenty years later, over ten thousand computers were in operation, in the United States alone.

The point has now been reached at which the computer possesses spectacular power as an information-processing tool, and as a logical system. There is even a tendency to be seduced into supposing that the computer mode of information-processing is superior to that of

human functioning. This kind of thinking is strongly supported by, for example, things like the legendary chess-playing computers, which learn from their mistakes, modify their own strategies and tactics on the basis of experience, and eventually become extremely difficult to defeat. Similarly, the existence of computer Chess-Olympics, in which computers are pitted against each other (or rather, programmed against each other) to determine the chess-playing computer champion of the world greatly influence the public image of computers. Again, the "artificial intelligence" of the computer has developed to a point where one such program "generated a new proof of a Euclidian theorem which was neater than Euclid's own proof" (Martin & Norman, 1970, p. 46)!

The computer mentality

According to Barrett (1968) one result of this change of events is the development of what he called the "computer mentality". He defined this new kind of human consciousness in the following way:

> There are two major sources of the computer mentality. The first is natural selection. Computer programming is an exacting profession, one that appeals to those who possess the capacity for meticulous attention to detail and a willingness to adapt to the rigid means of communication dictated by the computer. They are fascinated by the complex gadgetry and language. The second is environmental, the computer mentality comes gradually to accept the idea that the whole world can be understood in the same terms as the computer. Computer mentality looks for and finds the pervasiveness of mathematics, the rule of logic and order, and the simplicity and predictability of the most complex psychological and social processes.

What Barrett is drawing attention to, in fact, is that a kind of cult has developed around the computer, in which there is a strong tendency

to expect people to modify their way of functioning in order to be compatible with the computer, rather than modifying the functions of the computer to make them more amenable to human ways. The tremendous speed, accuracy and flexibility of the modern computer have all combined to shape the present form of the relationship between man and computer -- the conversion of accolytes to the computer mentality. As far as the man-machine interface is concerned, a major result of this is that the design of the interface has been left entirely in the hands of the engineers. The considerations, for example, which dictate the design of teletype terminals are not those of ease of usage by the human operator, but rather are matters like economy of core usage, amenability to real-time operations, speed of function, and so on. In terms of the computer mentality, things like the predispositions, prejudices, attitudes and emotions which the human user brings to the interface are unfortunate defects that have plagued man for a long time, that reduce his efficiency of function, and that make him a rather unsatisfactory device with which to interface computers!

While use of computers was confined to a small group of converted devotees who restricted themselves to the Computer Centre, this state of affairs was a matter of little concern (except perhaps to those who were worried about the mental health of the computer types). However, the extent to which the ordinary man in the street is now beginning to interact with computers is increasing greatly. It is for this reason that the kinds of issues emphasized by Weiss have begun to assume considerable importance . There are a number of ways in which

the computer is now beginning to enter the lives of a wider and wider band of the population at large, and some of these are summarized in the following section.

Computer penetration of life

The first basic use of the computer in information handling is as an information storage and retreival device. In this use it can be conceptualized as a kind of library, or even as a book with an unusually elaborate index. It can store large quantities of material beyond the span of an individual memory, and then retreive them according to, for example, some indexing system supplied by the user. A proper use of key words and similar devices makes it possible for the array of information to be individualized to the needs of a particular user. In medicine, for example, physicians in some cities can now supply a list of symptoms to a computer diagnosis centre, have them checked out against stored lists of symptoms forming various syndromes, thus permitting computer-assisted diagnoses to be made.

A second related use of the computer is an an information-processing tool. The computer can be used to assemble, organize, and analyze masses of scattered, apparently unrelated or simply unorganized information, into usable data sufficiently organized for human users to read, store, and utilize them. This may even involve carrying out complex statistical analyses which might otherwise be virtually impossible. For example, computers are being used to analyze responses obtained in opinion polls, and systems for doing this have been developed even when the questions in the polls are of the open-ended kind,

rather than the multiple choice kind. The "general inquirer system" (document), for example, analyzes natural language responses to opinion polls. Similarly, business firms can now subscribe to computerized systems which analyze market trends in their fields and facilitate estimating and similar functions.

A third role of the computer in everyday life involves the machine's function as a supervisory and control device. In this situation, the computer regulates the function of other devices, without itself actually being the instrument of communication, or carrying out the particular actions involved. Examples of this kind of functioning include computer control of traffic lights, in which information about the flow of traffic is transmitted to motorists via computer-controlled traffic lights. A second example involves the telephone switching operations, in which the flow of telephone messages is regulated by computer, and finally,computer-controlled type-setting, in which input to the system at the wire service end may actually be in coded form, so that what is received is not a message in "clear" for human typesetting, but a series of impulses that go straight to the receiving computer, which then sets type in natural language.

In all three of the functions discussed in preceding paragraphs, the major aspect of the computer participation lies in its ability to make decisions. These decisions are based on the particular needs of a specific situation and involve comprehensive and rapid analysis of information about the situation. Thus, traffic may be re-routed by a new route never before used by human controllers, on

the basis of a unique, atypical pattern of flow. Similarly, a set of unexpected cross-categories and responses to an opinion poll may be analyzed by the computer through its ability to attend to characteristics of the questionnaire not apparent to human analysts, or too multitudinous to be carried in the memory. In fact, then, a key property of computers is their ability to make decisions and to change their responses according to the particular needs of a particular user. This property is not seen in other information-devices which people have grown accustomed to using. The decision-making ability of the computer has contributed largely to its widespread application in the areas of education, medicine and dentistry, the Armed Forces, and so on.

Computers and teleprocessing

Until recently, however, the computer has had one serious drawback as far as its capacity to function as an everyday device is concerned. It has, in the past, been very much the esoteric darling of a small clique of highly specialized users. It has conventionally been necessary for anyone who has wished to use the computer to come into close physical proximity to the machine, and to be the master of highly specialized communication processes. The computer has, in fact, lacked any mass communication aspects.

However, this state of affairs is now changing rapidly. A key factor in that change has been the development of remote teleprocessing. In remote teleprocessing, the computer user is linked to a central machine by a terminal device, which may be a typewriter key-

board, a cathode ray tube, a ticker-tape device, or one of a number of other such devices. The terminal and the computer may be hundreds of miles apart, linked by telephone lines or some other similar device. Examples of this kind of separation of user and main-frame machine have been in the teaching of students in Regina, Saskatchewan, by a computer located in Edmonton, Alberta, 496 miles away. Another example involves Eskimos in Inuvik who are now linked to the University of Western Ontario, 2,800 miles away, via a teleprocessing link-up to the University computing centre.

The computer has certain tremendous advantages in these kinds of linkages. It can receive feedback from a user and modify the contact with him on the basis of that feedback. It can compare his responses with a list of anticipated responses and respond appropriately, or handle unexpected responses effectively. It can refer a user to other sources of information according to his particular needs, and so on. It can also co-ordinate the number of information devices such as TV screens, movie projectors, and so on. In fact, the computer has the capacity to make the information-exchange process between machine and user extremely idiosyncratic to a particular recipient, and thus to individualize the whole process in a way which is inconceivable with other mass communications devices currently in widespread use. There has even been speculative talk of a system of mass teleportation in which actual objects (or even conceivably people) would be transported via particle flows and energy modulation such as is seen in radio, with the whole system under computer

control. Although this is a science-fiction speculation at the present time, the development of the supersonic transport must have looked like a wild speculation at the time of the first flight at Kittyhawk. In any case, remote teleprocessing has enormously increased the capacity of the computer to interact with the ordinary man in the street, rather than to confine its interactions to a small group of devoted specialists.

This great increase in the capacity of the computer to interact directly with the general public has been greatly facilitated by two major technical developments. The first of these involves the area of cost. Extremely large computer systems are very expensive, and require high levels of usage to justify their cost. At first glance, this seems to rule out teleprocessing by individuals or organizations who do not have very large financial resources available. However, a single computer configuration can be jointly used by a number of users through what is known as "time sharing". This may take the form of a consortium of users sharing the costs among themselves to provide themselves with computer services. It can also be achieved by renting time from a commercial time-sharing company, of which there are in excess of 100 in North America (Hamblen, 1971). Large systems like that in project PLATO at the University of Illinois, for example, permit no fewer than 4000 remote terminals to operate simultaneously (and still leaves enough core free for normal data-processing operations). Less than ten years ago, 32 terminals connected to one computer would have been considered a large number.

The development of such large systems raises the possibility of huge computer networks involving, perhaps, network companies renting time to users in something the same way as radio and TV networks do now. Associated with this is the image of millions of receiving sets in the form of remote terminals situated in people's homes, in their offices, in the schools, and so on, all linked to the central network broadcaster in something the same way as radio and TV sets are linked to the networks now. The home receiver could, presumably, be in the form of a TV tube or a typewriter terminal, or even a tailor-made, printed-on-the-spot newspaper. One tremendous advantage of such a network would be that individual users would be able to modify the "programs" they received to suit their particular needs. (This general line of argument has been spelled out in detail in, for example, Cropley (1972).

The second area in which advances have greatly increased the capacity of the computer to be available to the man in the street has involved advances in programming languages. Many languages suitable for teleprocessing are available. However, in the past, they have tended to be quite unlike the ordinary everyday language of the human user. Computer languages have, in fact, been abstractions from natural language, in a coded form. However, some recent arrivals on the language scene have great promise for permitting communication between man and computer in something very close to the natural language of the user. Furthermore, these more recent languages greatly facilitate interactive relationships between man and machine, in which the com-

munication is something like an ordinary conversation. An example of one such language is that of APL, which has been described by one authority (Hunka , 1967) as "the ideal user's language". For the purposes of the present report, the peculiar properties of APL are that it is exceptionally capable of supporting conversational interaction between man and machine, and that these interactions are couched in something approaching natural language. Furthermore, the machine can be programmed in such a way as to make a wide variety of alternative responses to a user available to the machine, so that it does not simply repeat stock phrases over and over again, but actually appears to be participating in a conversation. (It is not suggested here that APL is the only language which has these properties. It is cited primarily as an example.) A fuller account of the properties of APL has been given elsewhere (Gross, Cropley, Hebb, & Palmer, 1971, pp. 124-125).

What this all amounts to is that recent advances in information science, predominant among them the development of teleprocessing techniques both in the area of hardware and software, have given the computer potential to function as, in effect, a mass communication device. In the past, the machine has not had true mass communication potential. What has been lacking has been the ability to communicate with very large, scattered audiences of non-experts. The telephone or TV, for example, could scarcely have had the impact on human lives that they have had, if they had remained highly technical devices, requiring lengthy training for their use, and centralized in one or

two very large rooms in a few key cities. However, recent growth in computer speed and core size, along with the developments in the field of teleprocessing, seem to be leading to a situation in which the computer can now assume a new role in human life. In fact, the computer has already reached the shop floor of the factory, the counter of the bank, the order department of a supermarket, the general manager's office, and so on (Martin & Norman, 1970). People are already growing accustomed to being billed by computer, and to having many of the cheques which they receive prepared and dispatched by computer (with the many amusing stories that have resulted from computerized errors in these areas). Students in schools are becoming increasingly accustomed to some degree of interaction with terminals, even if only in the library, rather than as a normal tool of their teaching. Furthermore, in the teaching area, the computer is by no means confined to large urban centres, but has been successfully used, for example, on the Canadian prairies (see Cropley and Gross, 1970).

Feelings about computers

The public have not been unaware of the fact that their lives are beginning more and more to involve computers. Furthermore, psychologists, communications experts, and indeed, governmental agencies have begun, in recent years, to attempt to grapple with some of the kinds of issues that Weiss (1971) urged should be examined. (See for example, Baer (1972), Martin & Norman (1970), Parkman (1972) and, of course, the 1972 report of the Canadian Department of Communications task force on "Privacy and Computers" (1972).) Indeed, the present

report is a further example of growing interest in the whole matter of people and computers. Basically, as Parkman (1972, p. 5) has pointed out, it is possible to discern two extreme reactions, extremely favourable at one end, extremely unfavourable at the other, with various in between shades of the extreme reaction occurring in various people. As Parkman (1972, p. 5) put it "The notion that there are machine processes that bear ever closer resemblances to human though disturbs some people and exhilarates others." There is little doubt, again to cite Parkman, that (p. 6) "new developments ... seem to have the potential for reshaping man's place in the universe and altering his idea of himself".

For some observers, these "new developments" hold out hope of the millennium, but for others they contain a distinct threat to the idea of "man's inimitable gifts" (Parkman, 1972, p. 6). This has sometimes reached the extent that some individuals experience a state of alienation from technology as a result of which they reject it, arguing, for example, that the computer is anti-creative. Again and again, the question of individual rights versus technological advantage arises when technological advances, especially in the area of computers, are discussed. As Cropley (1967) has pointed out, some of the same ideas may be seen in recent increased interest in the topic of "creativity". Apparently, the concept of alienation is of considerable importance in understanding the relationship between man and machine. Among some individuals, there is a strong feeling that increasing computerization of life is leading to a devaluation of the characteristically human

kinds of functioning such as emotion, intuition, and so on, and an excessive emphasis on logic, clarity and similar properties. One of the results of this is a feeling that people are increasingly being estranged from a truly human way of life.

This rejection and even fear of the computer has recently had vigorous expression in terms of fear of invasion of privacy (see, for example, Parkman, 1972, p. 146). These fears have seen summed up and evaluated in a recent report sponsored by the Federal Government of Canada (see the report of the Task Force on "Privacy and Computers", 1972). Much of this fear clearly has at its source a feeling that the computer can never exercise discretion, show judgement or even pity. As Vogel (1973, p. 17) has put it "computers neither forget nor forfive". The task force report already referred to used dramatic language like "information pollution" and "privacy crisis".

Summary

The basic argument of the present report, to this point, may be summarized in the following way:

1. Contemporary life is increasingly being penetrated by the computer.

2. This penetration is going on at increasing speed, particularly in view of the advances in teleprocessing which have occurred in recent years.

3. Computer technology has reached the point, in fact, at which the computer may, in the next few years, become as much a part of everyday life as, for example, the telephone or the TV.

4. In the main, as was apparently the case with the other two communication devices just mentioned, minimal attention has been given to human factors in this new role for computers.

5. In fact, the broad spectrum of public opinion may be regarded as a dichotomy, ranging from warm approval at one end, to alienated rejection at the other. An example of increasing public resistence to information technology is to be seen in the area of invasion of privacy, and the recent flury of investigations and reports in that area.

6. Fears concerning the effects of computers on people are, in fact, well founded. Experience shows that the effects of widespread penetration of human life by a new information device are quite profound.

7. To date, the main thrust of investigation of the man-machine interface has been essentially dominated by engineering. Thus, the key issues which are controlled at the interface are not the comfort and psychological well-being of the user, but the efficiency of machine design from the point of view of factors like cost-saving, time-saving, engineering efficiency and elegance, and so on.

Purpose of the report

The basic purpose of the present report is to outline some of the human factors which the psychological literature suggests are of major importance in the man-machine interface. Although no empirical test of hypotheses advanced in the following sections have been carried out, some of them are more than simply abstract and essentially impractical theorizings about men and machines. On the contrary, understanding of the psycho-social factors involved in the man-machine interface seems to have clear implications for the actual engineering and technology of that interface. Unfortunately, however, some of the psycho-social implications may be directly opposed to what would be regarded as good engineering practice. For example, it might well be shown eventually that human beings would find the interface psychologically more tolerable if the machines were sometimes hesitant,

awkward and stumbling in their responses. However, the idea of designing a machine to do its job inefficiently would probably be an engineer's nightmare, so that, as long as control of what happens at the man-machine interface relies essentially in the hands of the engineers, it is unlikely that the interface will be designed in ways that foster the psychological well-being of users, if not that of the engineers themselves.

The following sections of the report are concerned with an analysis of the man-machine interface in essentially psychological terms. These variables may be considered as being of two kinds. The first set of variables consist of those factors which the individual brings to the interface as a result of his own on-going psychological organizations (attitudes, expectations, mood, intelligence, and so on). The second set of variables consist of those factors in the interface situation itself which provide cues that are interpreted by the human user in terms of the on-going psychological states just mentioned. To put it in a nutshell, as a result of pre-existing psychological organizations, the human user interprets and structures his interaction with the computer. This structuring is based on the psychological cues contained in the computer situation, so that the human response to the interface depends only partly on the objective properties of the interface, and substantially on the particular psychological status of the user, and the way he interprets the interaction situation. If, for example, the human user perceives the machine as threatening, say by providing a challenge which he may not be able

to meet, the user is likely to respond with anxiety or hostility. Subsequent analysis of the psychology of the man-machine interface will be organized along the basic dichotomous lines just spelled out.

III RESEARCH METHOD

Design of the study

The "research" strategy employed in the preparation of the present report did not involve any experimental work. It consisted basically of gathering information in the area of computers and people. This was carried out by the use of three information-collecting procedures. The first consisted of a search of abstracts in areas like Human Engineering, School Learning, CAI, Industrial Psychology, Human Factors, Technology and Society, Computers and Society, and so on. A review of the literature was carried out in this way. Letters were subsequently sent to some 30 authorities in these areas, whose names had been obtained by searching abstracts. Finally, loosely structured interviews were conducted, on an informal basis with a nmmber of individuals (including a stockbroker, a secretary, a teacher, and a student) who have occasion to use teletype terminals in their work. This is a simplified version of the opinion-polling technique developed by Knapper and Cropley (1973).

A partial list of the journals searched follows:

Applied Ergonomics
Journal of Applied Psychology
Journal of School Psychology
Education and Psychological Measurement
Human Factors
American Journal of Psychotherapy
Perspectives in Defense Management
Ergonomics
Annual Review of Psychology
American Psychologist
Occupational Psychology
Programmed Learning
Scientific American

Public Opinion Quarterly
Science Journal
Administrative Science Quarterly
Bulletin of the Menninger Foundation
Alberta Journal of Educational Research
British Journal of Mathematical and Statistical Psychology
CAUT Belletin
AEDS Journal
Journalism Quarterly
Journal of Educational Psychology
Computers and Automation
IEEE Transactions on Human Factors in Electronics
Contemporary Issues in Educational Psychology
British Journal of Educational Psychology
CAI Centre Technical Report
IEEE Transactions on Man-machine Systems
Dissertation Abstracts International
U.S. Army BESRL Technical Research Report
U.S. Army Human Engineering Laboratories Technical Memorandum
Washington University Department of Psychology Technical Report

Only limited documentation is carried out in the text itself. However, a list of papers read, research reports studied, and major texts utilized is included as a bibliography at the end of the report. Precise documentation is limited in the body of the report because an attempt was made to integrate and co-ordinate material from a wide variety of sources into a relatively unified whole.

IV RESULTS

Findings are reported in two broad sections. The first is concerned with factors in the situation itself, the second with psychological characteristics of the human user.

Situational factors

Process variables. The first set of psychological parameters operating at the man-machine interface involves what may be called "process variables". These are factors that relate to the kind of things that the user actually does, and the psychological nature of his actions during the interface. Some of these process variables will be discussed in general terms in the present section. One such key variable is that of the context in which the interface is experienced. For example, the user may feel that his participation is compulsory or voluntary. He may see himself as being tested by the machine on behalf of, for example, his employers. It is apparently important whether or not the context in which the interface takes place involves the use of the machine as a simple adjunct for brushing up knowledge or supplementing information obtained in more conventional ways, or whether the interface is the primary mode of operation. In general, where the user feels that his use of the machine is voluntary and that it is simply a supportive tool, acceptance of the interface is good.

A second such process variable is that of the passivity or

activity of the user. Where he sees himself as essentially passive, for example acting basically as a clerk or a feeder of information into the computer assembly line, the human user is more likely to feel hostility and resistence to the interface. Again, a third process variable is that of the degree to which the user is able to "escape". Behaviour at the man-machine interface has to be extremely "reality-oriented". The kinds of behaviours demanded of the human user are extremely highly specified, and must be followed very precisely. There is no room for day-dreaming or, for example, manual clumsiness in using, say, a teletype terminal. In connection with this process variable, personality variables in the user like need achievement are heavily involved. The user who has a high level of need to do well and to master the situation is confronted with a device which requires extreme accuracy and care on his part. He cannot "escape" by varying the actions he carries for, if he does, the machine will "reject" him. In the high need achiever, this seems frequently to produce embarrassment and even a feeling of humilation or personal failure. Interviews with users like, for example, clerks in a stock-broker's office, suggest that the machine is quickly seen as an ominous, ever-present inescapable tyrant, that subjective feelings of failure and humiliation on the part of users often result, and that strong hostility towards the machine develops to the point where it is treated as though it is an unpleasant person who has come to work in the office.

A fourth process variable involves the credibility of the whole system. Where the user believes that he is doing something valuable

and worthwhile, for example as a result of a pre-existing disposition towards the "ain't science wonderful" point of view, the interaction with the machine has high credibility, is evaluated as worthwhile and is enthusiastically accepted. Where the machine is seen as a new-fangled gadget, which has been forced upon the user, and which he knows deep in his heart cannot do the job anywhere near as well as it was done before, rejection of the use of the machine and personal hostility towards it are high.

These process variables may themselves be summarized in the following way. Where the human user feels that he is the master of the situation and that he is doing things rather than having things done to him, and that this is more or less of his own free will, acceptance of the man-machine interface is good. One interesting concept used to unify these process variables is that of creativity. Although it may seem to be stretching the point, a number of writers have argued that computers are, in a sense, anti-creative. This point is relevant in understanding process variables at the interface. Subjective interpretation of their own interaction with terminals on the part of users interviewed for the purposes of this report indicated that, where the interface makes the user feel that he is, in a sense, being creative (i.e. he plans, controls and varies the situation, rather than simply reacting to the domination of the computer), and thus sees the interface with the computer as simply an aid to his own "genius", the interface is not experienced as threatening, humiliating, or frightening.

These comments suggest that some of the following intrapersonal

variables would be appropriate for an empirical study of psychosocial factors at the man-machine interface:

1. Risk taking
2. Radicalism versus conservatism
3. Authoritarianism
4. Divergent-convergent thinking
5. Attitudes towards technology and science
6. Need achievements
7. Extraversion-introversion
8. Impulsivity

The computer as a "personality". A second set of factors in the actual interface situation involves not the nature and organization of the interaction which was discussed in previous paragraphs under the title "process variables", but the actual "style" of the computer itself. One useful way of considering the psychological variables in this area is to do what many relatively unsophisticated users do, and to treat the computer as though it were, in a sense, a person with a personality of its own. Interviews with ordinary, man in the street users conducted in the course of preparing this report suggest that this is precisely what a very large majority of users outside the ranks of computer specialists actually do. The computer, as a personality, is rigid, inflexible, compulsive, authoritarian, and cold and emotionless. It is irritatingly and smugly infallible, totally unsympathetic towards users' human frailties, strictly logical, and totally self-centered. It deals ruthlessly with user errors, and even when the error is actually in the machine system, it irritatingly persists in writing out messages that imply that the user is at fault. It is maddeningly fast in its actions, and can humiliate any human typist by the speed with which it writes out messages. All in all, then, the

interfacing devices by which non-specialist human users are confronted possess very poor interpersonal skills! In a sense, then, the question of making the man-machine interface psychologically more congenial for human users is a matter of improving the "personality" of the interfacing device.

One particular problem for human users in this area seems to be the fact that computing machinery is so rapid in, for example, its ability to type responses to a human user, by comparison with the rather frail human efforts in the area. Furthermore, it is cold and unsympathetic in its treatment of users, even when they are nervous and flustered middle-aged women or flighty adolescent girls! The result of this cold and emotionless, ultra-fast and accurate behaviour on the part of the interfacing device is that human users frequently feel resentment and even dislike for the computer system. In this respect, it is interesting to notice that machine failures which result in errors of function are often greeted with glee by the users. Some persons interviewed reported, for example, that they would stand and gloat over a malfunctioning teletype terminal. Another said that he gets great pleasure out of pulling the plug out of the wall when the terminal annoys him too much by refusing to accept his fumbling efforts at communication, and that he then stands and stares at the machine while muttering something like: "Take that, you s.o.b.!"

Viewing the interface system as having a personality of its own, has a number of direct implications for design of the system to in-

crease user acceptance and psychological comfort in the interface situation. For example, it seems that a system which was more variable in its response time, sometimes even taking a relatively long time to respond, or even apparently hesitating and having difficulty in responding, would provoke less hostility and anxiety in human users. Similarly, a system which actually made some mistakes, for example typing errors, and then acknowledged those mistakes, admittings its own fraility, would be similarly more emotionally-acceptable to human users. At the present time, many of them persist in treating the computer as a person and responding to it as they would respond to a person with a similar personality. Thus, if the major aim of systems designed were couched in terms of the psychology of the human user and his psychological comfort, engineering efficiency might well have to be sacrificed in order to create a more "human" computer personality.

User factors at the interface

Anxiety. One of the most obvious differences between a computer logic system and a human logic system is that the computer operates strictly in terms of "cold" cognitive processes, whereas the human being is a system employing "hot" cognition. Thought processes in human beings are accompanied, in fact, by emotion, and this is what makes them "hot". One major emotional reaction to the man-machine interface is that of anxiety. Human users very frequently report that they feel that they are being tested. There is a strong feeling that a man is better than a machine, and that therefore a user has an obligation, as it were to the human species, to master and dominate the

machine. A strong sense of competition develops. The typical response to, for example, an error in entering a message on a teletype keyboard with the resulting rejection of the message by the computer system, is a feeling of failure.

Over a period of time, with intermittent experience of failure, many human users develop high levels of anxiety. The situation is one of intermittent negative reinforcement, with errors in using the system occurring only occassionally, and at unpredictable intervals. The result is development of high levels of anticipatory anxiety. This reaches the point in some users at which they are afraid to use terminals at all, and experience a build-up of tension when they know that they are shortly going to be called upon to use a teletype device. One person interviewed, for example, reported that a secretary in his office had developed the habit of leaving the office at precisely 8:30 a.m. each morning and locking herself in the bathroom. At 8:30, other offices with whom this particular office was linked by teleprinter normally came on line and reported in! At present, then, for many users, the major emotional factor involved in the man-machine interface is that of anxiety.

Alienation. As has already been pointed out, one of the features of modern life is an increasing resistence to technology. In many people this takes the form of actual fear and resistence. Among those who see one of modern life's greatest problems as reduced interpersonal contact, the increasing necessity to interact with computers as part of everyday life is seen as a movement which is steadily making

people more and more alienated from each other and from their environment. Thus, in fact, it is possible to say that substantial sections of the population have rejected technology (Parkman, 1972, p. 153). They are hostile to computer technology, for example on the grounds that it is anti-creative, and are, in fact, strongly alienated from the man-machine interface. Thus, such people are very sensitive to the cues in the engineering and function of the interface which suggest de-humanization. Process variables like compulsion, or apparent reduction of the human user to the status of a mere tool of the computer, are quickly detected by such people, and are interpreted as further proof of the alienating effects of modern technology. Their pre-existing attitudes predispose them to interpret features of the computer system in unfavourable terms.

The relationship of broad, on-going psychological states like anxiety and alienation to interpretation of cues inherent in the organization of the man-machine interface suggests that a number of psychological variables in users would be expected to be significantly related to feelings of hostility, rejection, and so on, when the computer system was utilized, as against feelings of satisfaction. Some of these are listed below:

1. On-going levels of anxiety
2. Prior experience with technological devices
3. Low levels of self-esteem
4. Need for warm emotional support from other human beings (succorance)
5. Internal-external locus of control
6. Level of affiliative needs

Age and sex. A number of the variables discussed in preceeding

sections imply that there may well be significant differences both between males and females in their psychological reaction to the man-machine interface, and also between cohorts of individuals of markedly different ages. The prevailing social division of sex roles is oriented towards emphasis on technological and mechanical interests for males, artistic and creative interests for females. Thus, it is possible to speculate that the man-machine interface would be particularly trying for the stereotypical female and less trying, or even attractive, to the stereotypical male. In fact, Cropley and Gross (1970) did find that there was a preponderance of males in a computer science class in which they conducted some research, and that those who volunteered to take instruction via Computer-Assisted Instruction were predominately male.

Similarly, the rapid increase in technology means that those who are presently elderly were reared in a world in which there were few technological comforts, the middle-aged in an environment in which there were still relatively few widespread devices in life. The very young or the as yet unborn however, will reach adulthood having been surrounded by a wide array of technological gadgetry for their entire lives. A simple example of this involves the fact that the present author did not see television until he was 21 years old, and did not live in a house with its own telephone until he was 27. By contrast, his children have never known an environment which did not include TV or telephone. The implication of this contrast is that many of the factors which human users bring to the interface will disappear in the

next generation. Among these factors would be ignorance and fear of technology, a clinging to the "good old days" when people did things by hand, anxiety that one will be incompetent in the use of the machine, and so on.

Thus, it is possible to predict that the key psychosocial variables just listed may disappear as relevant variables at the man-machine interface as a result of changing sex stereotyping and differing conditions of child rearing. What has been referred to here as "alienation from technology" may then come to be of increasing importance. This latter development would occur if movements like the burgeoning ecology movement continued to gain strength. Indeed, the report of the Governmental Task Force on Privacy and Computers in a sense implies this very point. The report suggests that there is, at present, no privacy crisis. It then refers to the "ecology crisis" which is said to have been ignored until serious damage had been done to the environment, and implies that strict control of information-science should be implemented prior to the development of a crisis in this area.

V IMPLICATIONS FOR ACTION

Machine personality

Although the immediately preceding comments on a possible drastic change in the key psychosocial parameters may partly invalidate the point, the first implication of this report is that there is a need to re-define the "personality" of the computer. Such a suggestion would undoubtedly encounter strong resistence at the engineering level, and would, presumably, involve increased expense along with pronounced technological inefficiency. However, there is a serious danger that, if no conscious effort is made to achieve some psychotherapy with the computer system, there will be increasing acceptance that the computer's way of functioning is legitimate and proper, and a consequent tendency to expect human beings to modify their personalities to match that of the computer. With the realization of the vision of "a computer in every household", it seems certain that drastic modification of social organization, the notion of, for example, creativity, the nature of work, mass communications, and so on will change. The real issue at the present moment seems to be the one of who will dictate the nature of the man-machine interface -- the engineer whose primary concern is for technological efficiency, or the communications psychologist whose primary concern is avoidance of psychological injury to the human user.

Machine design

Although it would clearly be Utopian to envisage a drastic revolution in machine design in line with the kinds of statements in the

previous paragraph, and indeed it is probable that some readers would regard them as absurd, it is possible to make statements about what the machine design features of the interface should be like if psychosocial considerations were predominant. In very broad terms, machine design would have to be turned away from maximum speed, maximum efficiency of core usage, shortest possible response time, and so on, and oriented towards minimizing negative reactions in human users.

Testable hypotheses

Preceding sections of this report contain a number of fairly specific statements which would readily generate empirically testable hypotheses. In the present paragraph these will merely be summarized and organized. The first set of empirical studies would involve an attempt to demonstrate the extent and nature of negative psychological reactions to the man-machine interface. It is possible that computer specialists might find it surprising that non-specialist users do experience negative reactions to the interface. On the other hand there may well be a tendency to exaggerate the problem. A second broad empirical question in this area is that of testing the connection between some of the specific variables listed in earlier sections and psychological reactions to the interface. Cross-sectional studies involving differing age-cohorts would also be of considerable interest in indicating whether a good deal of the problem may not, in fact, be self-remedying, as younger users participate in the interface.

A third broad area for empirical investigation involves examination of the relationship between specific kinds of interface engineering and

user reaction. In the same vein, evaluation of the relationship between user attitudes and feelings towards the interface and different kinds of interface devices is needed (e.g. cathode ray tubes versus teleprinters, etc.). In particular, it seems very likely that different configurations at the interface will effect different people in different ways. Thus, there may be no single most desirable form of the interface from a psychological point of view, but rather, a variety of configurations to match the variety of personality organizations to be expected in human users. Similarly, empirical study might well indicate that different areas of usage (e.g. Computer-Assisted Instruction, computer-controlled shopping, computerization of stock market activities, and so on) might well be shown to involve different psychologically optimal designs of the interface. Currently, investigation of such differences in the design of the interface is primarily based on systems analysis of the logical operations of the computer involved, and not on the illogical operations of the human user.

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