

# Computers and psychology

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This paper is based upon the Opening Address to the Joint Computer Conference on *The impact of the users' needs on the design of data-processing systems* held in Edinburgh, 31 March–3 April 1964.

For anyone concerned with computers, this is a particularly auspicious occasion. Not merely because it promises to be a very useful conference, but because its purpose and make-up are exactly what we want. First, it brings together the two threads of design and use, whose connection needs reassessment at this time; second, because it is a combined effort by three thriving bodies: the well-established Institution of Electrical Engineers and British Institution of Radio Engineers, and their younger brother, whose President I have the honour to be, the British Computer Society. For us it is a particularly happy occasion, because it fits our ethos. It is still very difficult to analyse the science of computing in any methodical way, because it is growing and its boundaries are ill-defined; but we provide a practical definition by being open to all who are interested in the subject; and nothing suits us better than a conference where the varied interests of the engineer and the user are equally represented, without too close a distinction; because that is our nature.

## The third generation of computers

The subject of the conference is well-chosen at this time. The third generation of computers is coming up, and it needs the combined efforts of the designer and the user to determine what shape it shall take. I do not propose to say anything about the more technical matters, in which I have no personal competence; but there are one or two major questions which it is worth raising. First, does the future lie, over the next decade, with large or small computers, or with both? This question is not simply technical. We may take it for granted that, in general, any kind of operation is more cheaply done on a large computer than on a small one, provided that the large computer can be fully loaded; second, that over the next decade problems of time-sharing and communications will be largely solved, so that there will be a *prima facie* case for feeding most data for processing into a large computer, often at a distance and not necessarily one's own. It is also certain that communications between computer and computer will become far commoner: a guess has been thrown out and attributed to more than one expert, that in ten years' time telephone wires in America will be carrying more traffic between machine and machine than between man and man. But it is not so certain that everyone will be willing to depend on someone

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else's computer, or that communications will be cheap enough to offset the greater expense of having one's own computer: the small man may still wish to have a small computer. Next, we may assume, and hope, that over this period there will be a general move towards the goal of integrated data processing. In large concerns this will certainly encourage the use of large computers for all data-processing operations, and many of the data will come direct through transducers from physical operations. But there may still be room for smaller special-purpose computers. Are we sure that we shall in due course want to move things and to produce statistics from the same central processor? The requirements of complication and reliability are different.

The next generation, therefore, and more importantly the fourth generation which will follow it, are still pretty undetermined. There may still be room for many different types and sizes of computers; the one thing that is sure is that if systems are to develop as rapidly as they should, different types of computers must be able to talk to each other. To which I should add the obvious point that systems tend to lag behind hardware; it is there that we need our greatest effort. Society in this country, academic, governmental or commercial, is not so organized as to put the necessary impetus behind the study of systems and applications. Every day technology provides us with more accurate guns for hitting our targets; and for the most part we go on taking them by the barrel and bashing on the head such beasts as are slow enough to stay within hand-reach.

## Man-machine communication

Leaving these problems as unsolved as you would expect, I should like to concentrate on the subject of your last sessions: input and output, in the widest sense of the phrase, including man-machine communications. These unquestionably are weak links in our chain, particularly in data processing, where the relation between the amount of data to be processed and the complication of the processing is particularly unfavourable. Leaving aside altogether the horror of moving parts, nothing is more depressing than to see a machine operating in micro-seconds which has to be fed by data made available to it by the human hand, working at human speeds. This particular bottleneck can be avoided in process-control and other similar procedures where transducers take the load and humans need not

intervene; but where business applications are concerned, there is no real way round as yet, except by making the computer able to receive data simultaneously from dozens of human inputters. This is excellent for a couple of dozen scientists with Flexowriters, but still pretty expensive when you want to process 50,000 vouchers a day. You can have turn-around documents where part of the material is provided in a form readable by the machine, and you can keep your files on tape; but fresh data originate in the human mind and are expressed, one way or another, by the human hand.

Now this leads one straight away to the fundamental differences between man and machine. The machine works, through a known system of circuits, by a series of recognitions of yes and no. Man works, by a still unfathomed circuitry of far greater complexity, by a series of recognitions of patterns. Dealing with a series of yeses and noes, man is slow and inexact; and his concentration on patterns makes him unreliable in recognizing lengths and sizes. The machine can deal with defined quantities and lengths, but is terribly bad at recognizing unequivocally significant identities of pattern where the sizes and quantities are inexactly defined, as they always are with human output. Further, this business of pattern-recognition is not simply one of sight and hearing; it runs through the whole structure of language, witness the appalling problems of machine translation.

The reconciliation of these two systems of input and output, human and machine, is clearly one of the great problems before us. We all know something of the technical attack on them, from the machine end. The first aim must clearly be to enable the machine to read type and print with speed and reliability, and perhaps to hear speech (though I rather doubt the utility of this, beyond an elementary level, in relation to its difficulty). Beyond that lie the reading of handwriting at one end and machine translation at the other, as useful applications.

### Help from the human sciences

But I rather wonder whether we shall have something to gain from the neurologists. Not by way of providing a computer-pattern of the process of thought, which we have given to them and which is doubtless useful; but it is dangerous for us computer men to use, since we know about machines already but not about the brain. But rather by way of a greater understanding of the human process of recognition, so that the machine can be made better able to deal with the system of signals which are emitted and received by man.

There is another way in which I am sure that we shall have to learn from the human sciences. I doubt if the psychologists have been asked with sufficient strength to study the interaction of man and computer. Computers have advanced so fast that those who live with them and are technically trained hardly realize the nature and strength of the psychological blocks against their adequate use, so far as the ordinary, untrained or arts-trained,

business man is concerned. The first block, which should disappear within a generation, but is with us now, is lack of familiarity. Something new comes into the world when one is middle-aged. It is so unfamiliar in concept that one simply assumes that one can never grasp it—and one does not. The next generation may know more or less about it, but it is familiar with the concept, and sets out to learn about it as about anything else. The first generation has a block, the second has not. A good example is relativity. When I was a boy it was understood, and one was told by one's elders, that the fundamental ideas behind Einstein's work were so difficult that very few people, and certainly no amateur, could begin to understand them. Yet probably every schoolboy nowadays attacks the special theory, at least, undismayed, because the concepts have sunk in and do not seem psychologically impossible. Computers, to many of the older generation to-day, are incurably unfamiliar.

The second block is the obvious one: a computer purports to put into an unfamiliar black box things which the ordinary business man did from his own knowledge. I think that his block is disappearing rapidly, if only because computers are fashionable; but one still sees signs of it—dare I say most of all in this country, which, in spite of its advanced technology, so far as the design of computers is concerned, drags behind almost all the advanced countries in their application, and tends to concentrate on the most elementary uses?

The third block lies in arithmetic. I deliberately put it no higher than that. No one expects the ordinary man to have a degree in mathematics; but what between methods of teaching and early specialization, a very large part of the nation emerges with a total unfamiliarity with the use of figures, beyond elementary accounting. Cambridge missed a chance last century when it abolished the double tripos. Anyone who has read Annan's life of Leslie Stephen sees what a deadly teaching it was, in classics and mathematics alike; but reformed, with modern methods, what a splendid and useful education one could have from a mixture of arts and mathematics. You would not then have monsters like myself: I got into the civil service by an examination, and spent most of my life in the Treasury, never having been taught any mathematics beyond the age of fifteen.

### Mathematical training

The mental block against mathematics, of which one so often hears, is surely avoidable by a saner educational programme, such as we may hope to see in action in a few years, thanks to the admirable work now being done on it. This should also abolish the utter lack of preparation of many intelligent people for any numerical process. I am certainly the only sample of this kind of ignoramus in the room; but we are the majority in the nation.

History is sometimes illuminating, and I suspect that we are still inhibited by the supposed strangeness and magic of numbers. When Plato, quite rightly, wanted

to impose a mathematical qualification on entry to his Academy, he wrote over the door "No admittance to non-geometers." Geometry was a sane intellectual discipline, derived from surveying, not from magic. Pythagoras added enormously to the understanding of numbers, but treated them as magic. Magic numbers lasted long, and thirteen is still unlucky. No one could manipulate numbers seriously till we had arabic numbers and algebra, which was late. Newton wrote the *Principia* in terms of geometry, which no one would do to-day. The significance of real and imaginary numbers was only understood quite lately by mathematicians, and they remain mysteries to the arts man. Therefore, I plead that everyone should support the rational teaching of elementary and logically expounded mathematics to a much higher age than is normally done for the arts men;

I believe that this is at least as important as the education, undoubtedly necessary, of more technologists. And let the psychologists play a full part in the process.

To sum up: technical progress is well under way, but it is no use producing a fine car unless people have been taught to drive. The technical process of teaching the ordinary man enough about computers, without making him an expert, which he need not be, is not too difficult, provided that he has a fair mathematical and numerical training, and provided the concepts are made familiar. If this can be done, in ten years' time or so you will have users worthy of the machines and systems which I am sure the industry will produce. If not, they may fall into the hands of specialists who will have no adequate means of communication with a large section of the decision-makers.

## Book review: Man-machine communication

*The Compatible Time-Sharing System—A Programmer's Guide*, by F. J. CORBATÓ *et al.*, 1963; 96 pages. (Cambridge Mass.: *The M.I.T. Press*.)

Readers of the *Computer Journal* who have followed developments at MIT will be aware of the pioneering work at present being done there with the object of bringing users into much closer personal contact with large computers than is normally provided by operating systems working on the batch-processing principle. Some readers may have attended the session on this subject which took place at the Joint Computer Conference recently held in Edinburgh, and seen the short film illustrating the work, together with the on-line demonstration via the transatlantic cable.

The Compatible Time-Sharing System is a pilot system whereby a number of users, sitting at teleprinters and Flexowriters in their own offices, may make remote use of an IBM 7094 computer. It is compatible in the sense that normal IBM programming procedures may be used, so that a user who is familiar with these procedures will feel at home, once he has mastered the method of controlling the computer from the keyboard. The system is evolving, and it is stated in the Preface that the present booklet, although not highly polished, is being presented now to assist in the evolutionary process. Its first purpose, however, is to serve as a user's handbook, and I can testify to its adequacy in this respect—bearing in mind the developing nature of the system—as a result of experience obtained as a user during six weeks spent at MIT last summer. The book will, however, be of interest to the wider circle of people who have heard of the Compatible Time-Sharing System and would like to know in more detail what is offered.

A short introductory chapter gives the motivation for the development of the system and describes the 7094 computer system on which it operates. This is provided with two banks of core storage (each of 32,000 words) instead of the usual one, so that there is sufficient room to accommodate the system programs and, at the same time, to allow the user the full 32,000 words for his program that he is used to on a normal 7094 system. There is, in addition, a disc file, and there are various devices, including a 7750 auxiliary computer, through which the consoles are connected. Included in the

second chapter is a brief description of how a user "logs in" to the system, and how he can create files of information which are preserved as long as he wishes on the disc file of the computer. One file might, for example, contain a program written in a compiler language; the programmer can make alterations to such a program, and he can cause it to be compiled and run, all by commands typed in from the keyboard. Results or diagnostic information, as the case may be, are printed out before his eyes. If the program needs a lot of running time, he can, when he is sure that it is working correctly, hand it over to form part of the background load on the computer, and receive his results in due course.

Chapter 3 contains a more detailed description of the facilities provided, and techniques for using them. From there the reader is advised to jump to Chapter 7, which contains a list of commands that the user may employ to initiate action in the computer. An *input* command, for example, would enable him to create a file of new information. An *edit* command would enable him to make alterations, and other commands would enable him to print out a list of all the files that he has stored in the computer, to print in full or part a particular file, and so on. Immediately following this chapter is an appendix, which gives an example of a session at a console at which part of a program is debugged.

Chapters 4, 5 and 6 go into more detail about the software facilities provided. Chapter 4 describes the various routines which form part of the supervisor. These are utilized by console initiated commands, but calls to them may also be included by the programmer in programs that he writes; in this way, he can perform operations on files which are not provided for in the command list.

The developments described in this book are only a beginning, and further development of hardware will be necessary before on-line time-sharing systems are universally applicable and acceptably economic. There is also much work to be done on scheduling-algorithms and means of protecting the system against overloading when too many users try to work at once. I am sure, however, that all who study this handbook, and are in a position to judge, will agree that Professor Corbató and his colleagues have achieved a marked step forward.

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