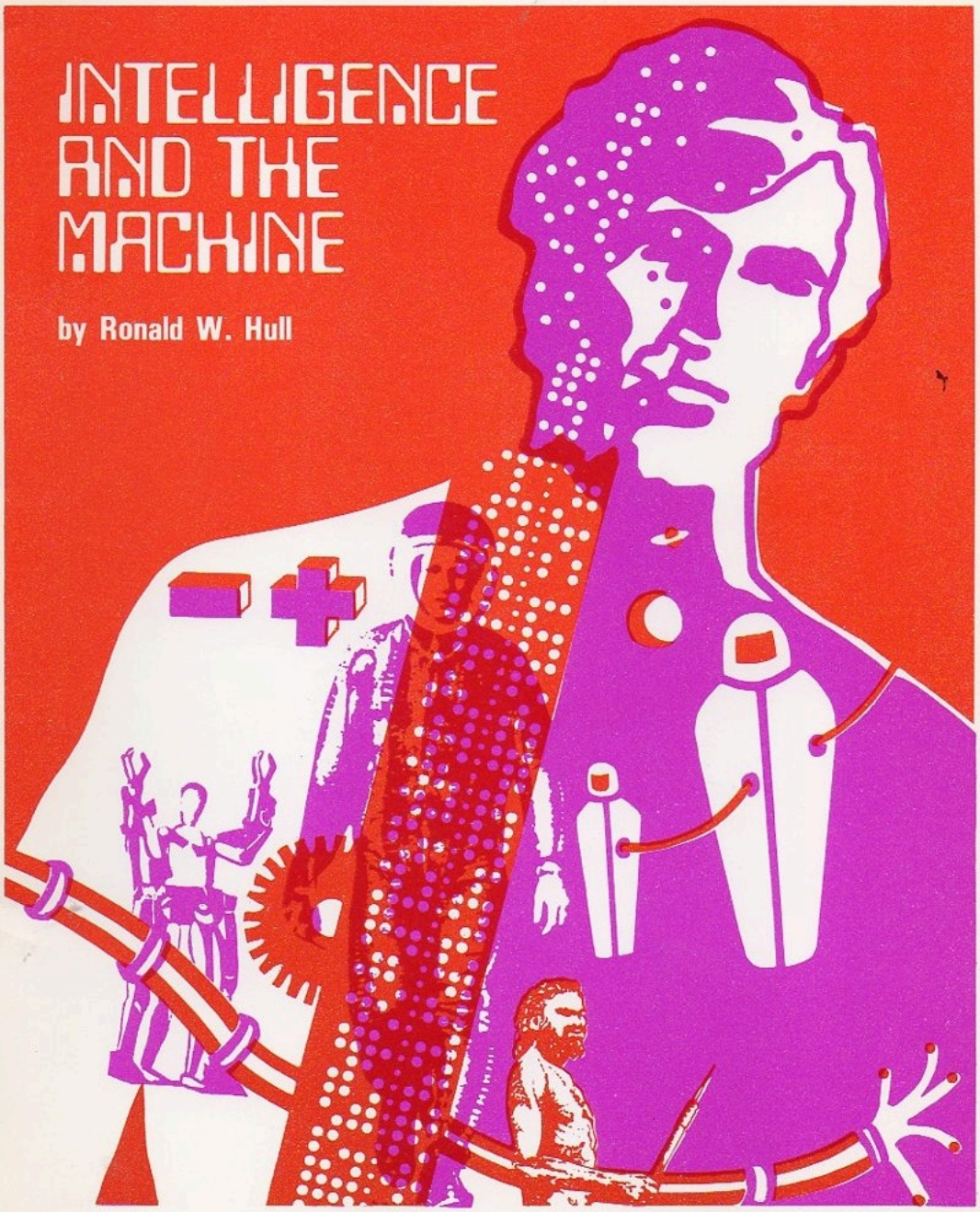
Technology and Education

Social/Cultural Issues **Bulletin No. 1**

INTELLIGENCE AND THE MACHINE

by Ronald W. Hull



Program for the Study of Technology and Human Resource Development
Curriculum Research and Resource Center

West Virginia University
Morgantown, W. Va.

Preface

This is one of a series of monographs published by the Program for the Study of Technology and Human Resource Development at West Virginia University.

The series consists of monographs related to the general topic of Technology and Education. There are three topical areas: (1) Curriculum Development; (2) Technical Processes, Procedures and Developments; and (3) Social/Cultural Issues.

The monographs are designed to serve classroom teachers and others concerned about the study of man, society, technology and education. Hopefully the publications will provide a base for enhancing awareness and knowledge about technology.

The question of *Intelligence and The Machine* was discussed as one of a series of seminars conducted at West Virginia University during the summer of 1972. The topic was selected for the first monograph because of the great interest on the part of all seminar participants and the fact that the questions raised are at the heart of the issue concerned with the man, society, technology equation.

Paul W. DeVore

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Introduction

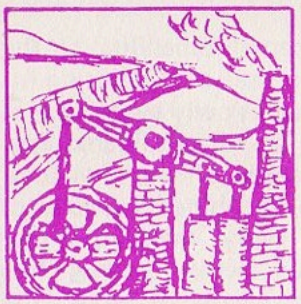
Man is slowly relinquishing his mental capability to the computer. To say this does not mean that Man is losing his intellect; in fact, his mental ability is still slowly evolving as it was when the first thought crossed his mind millenia ago. However, the power, accuracy, and speed of machines have given Man the desire to develop machines capable of replacing every mental/physical facet of his being, freeing him from the drudgery of labor. The human brain is the last holdout, the last part of the human body which has not been improved by machinery. The brain and its nervous system are exceedingly complex, but the exponential growth of computer development is staggering, rapidly closing the gap on several brain functions. Michael Crichton speaks of Watershed Week in July, 1969:

> *In that week, the information handling capacity of the world's computers exceeded the information handling capacity of all human brains in the world.* (The Terminal Man, *1972.)*

There are more "watersheds" to come, until the first "thought" crosses a computer's mind.

Background

It is difficult to say when Man first began to fear the machine. Possibly, when the machine's power seemed to slip from the hands of its maker, when things seemed to periodically get out of control. One cannot but marvel at the



goliaths of Cornwall, those perpetual steam engines of Newcomen, Boulton and Watt, with their power and consistency ranging far beyond their makers. The Luddites rebelled against the replacement of their jobs, their very livelihood, by the machine; this inhuman ability of machines has been challenged ever since.

Using mathematical and physical constructs of DaVinci, Newton, Wilkinson and countless others, Henry Babbage tried to put the accumulated machine knowledge of the

centuries into the first intelligent machine. This Analytical Engine was a failure, but it was a major step toward the mature genius of inorganic intelligence. Today, the compact size of a minicomputer, the calculating power of an IBM 370, or the complexity of an analog-digital hybrid computer system are still infants when compared with the complexity of the human brain. Still, some people are getting a little worried.

The Robot

The traditional way of thinking of machine intelligence is to model it after Man. The robot of science fiction, like some kind of perfect slave, was not only manlike (in the image of God), but he was generally programmed to be benign (5, p. 65). "Robbie the Robot" was the typical stereotype—

intelligent, indestructible, kind, and completely obedient—if only our cars would behave so well. Study of the physiology of humans and the mechanics of motion, however, quickly discourages an attempt to replicate the human being; it appears to be much better to attempt to get at the source of Man's power, his intelligence, then to replicate this brainpower and hook up the "thoughts" to the best machine(s) for the job.

Advanced Computers

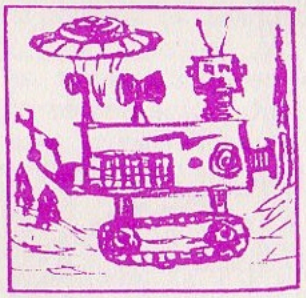
Since the breakthrough into electronics in the 1940's, there have been few dramatic changes in the digital computer. The Analytical Engine, in fact, mechanically possessed the logical characteristics of today's computers; it only lacked their efficiency. The real advances in modern computing have primarily been quantitative, rather than qualitative. For example, all of the "generations", so loudly proclaimed by the people making "progress" in computer design, have been merely improvements in efficiency and speed; the logic of operation still utilizes elementary binary mathematics. If it is possible for "digital" logic to lead us to intelligence how can we get a qualitative change toward intelligence by merely increasing speed and efficiency?

Dr. John McCarthy of Stanford and others are attempting to get a qualitative change in digital computers through improved programming and input-output devices. He says of their work: (4, p. 111)

> *Although our work in the artificial intelligence laboratory has been exceedingly complex thus far, we are still on the outermost frontier. However, basic principles*

must be firmly laid first. We have a long way to go; we are not sure when we will get there, but progress is steadily being made.

The progress he speaks of are in the two areas of intelligent processes and effective sensor-effectors. For instance, McCarthy has been working on self-improving chess playing programs which are good, but can be beaten by an average human player. Others are working on complex pattern recognition called "clustering" in Project Promonade at SRI. The Heuristic Denrils Project is attempting to program "intuitive" problem solving. There is also work on artificial eye, ear, and arm—progress on all of these is slow.



If we have gone as far as we can digitally, possibily the answer lies in analog computers. The development of sophisticated analogs have enabled us to land on the moon and may eventually lead us to intelligence. Analog-digital hybrids are now commonplace in space research. They have been used to help study the psycho-physical nature of Man (K.U. Smith's Cybernetics Laboratory at the University of Wisconsin).

To give you an idea of the difficulty of an intelligent machine, this machine would occupy the highest step of a machine development hierarchy: (Hull, 1970).

Level	Type	Operation
I	Manual	Completely operated by Man
II	Semi-Auto	Started by Man, self-powered
III	Automatic	Controlled by Man, Self-starting
IV	Automated	Adapted by Man, self-controlled
V	Cybernetic	Reproduced by Man, self-adaptive
VI	Ecologic	Programmed by Man, self-reproducing
VII	Autonomous	Self-conscious or "aware"

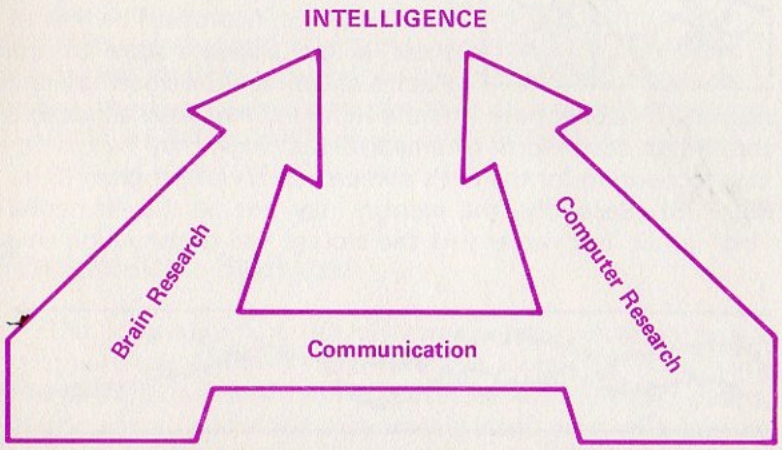
What level of computer development HAL 9000 had reached in Clarke and Kubrick's "2001: A Space Odyssey," we don't really know, but we do know that it is making some rather primitive "conscious" efforts to please its makers. Like

an unwise child, HAL bungles the task he takes on. As he does, a shudder runs through us. We begin to wonder about the consequences of playing with intelligence.

The Brain

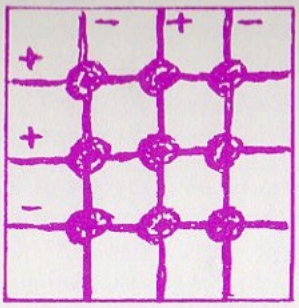
One approach to unlocking the mystery of intelligence is to study the brain. For a long time, the belief in a brain/mind dichotomy prevented meaningful work in this area. This dichotomy is rapidly fading. Work in several disciplines, utilizing experimentation with the known laws of energy and matter, have steadily uncovered the essence, bit by bit, of the brain. Just as the heart has been found to be nothing more than a complicated pump capable of being replaced by a complicated machine, so too, it may be with the brain. If we think of it purely in known physical terms, "The brain is a machine." (3, p. 229-30).

Dr. Dean Wooldridge, the former president of TRW, has advocated an interdisciplinary dual thrust approach to machine intelligence: (3, p. 236-7).



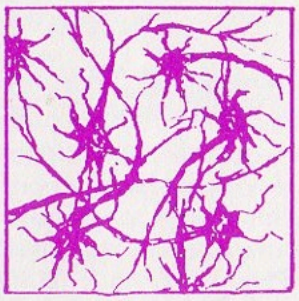
Wooldridge's Interdisciplinary Approach

To give you an idea of the problem of discovering the source of brain (and therefore machine) intelligence, we must begin at an elementary level. The neuron of the brain is an on/off device which can be considered analogous to the +/-



charge on a digital computer core "donut." Electronically manipulating these +/- charges by "and", "or" and "not" logical functions in a stepwise "program," we are able to perform logical processes such as landing a LEM on the Moon.

The behavior of an ant is far more complex than landing a LEM on the Moon. This behavior is almost human, if one is to believe Thoreau's account. However, if we asked a brilliant programmer to program the landing of a LEM on the Moon with only 250 "bits" of storage, logic, and control (an ant's brain has 250 neurons-a human's brain has 10 billion neurons), he would tell us we were crazy, let alone want to program the ant's life as Nature has done.



Fortunately, there are two ways to go—two ways to get more programming "freedom" and "power" from only 250 neurons. The first of these is the analog nature of the electro-chemical operation of the neuron. If neurons are variable-summing and have adjustable thresholds, some form of analog-digital logic may be operating, accounting for the ant's complex behavior program (3, p. 86, 235). Secondly, the neuron may not be the elemental "bit" at all, but rather just the storage and transmission area

for RNA (the unstable form of DNA), whose complex molecular sturcture could multiply the programmable power of the ant's 250 neurons 50 billion times! (3, p. 86-9).

All this work in brain research suggests that the road to machine intelligence may not be "electronic" (3, p. 234) or even "digital" (3, p. 235).

Consciousness

Wooldridge is one of the foremost advocates of destroying barriers by knowledge. The blood/brain, mind/brain, analog/digital, organic/inorganic, animal/human, and finally, human/machine consciousness barriers will fall on the way to machine intelligence: (5, p. 288).

> *And yet the brain is made up of atoms and molecules and nothing more. There is nothing in the most magnificent human brain but the matter it contains. If there is something called a "mind" or "personality" or even "soul," it is but a subjective interpretation of the consequence of the working of that matter, and we can learn about these mysterious words only by studying the matter.*

The study that he has done leads him to conclude: (3, p. 240).

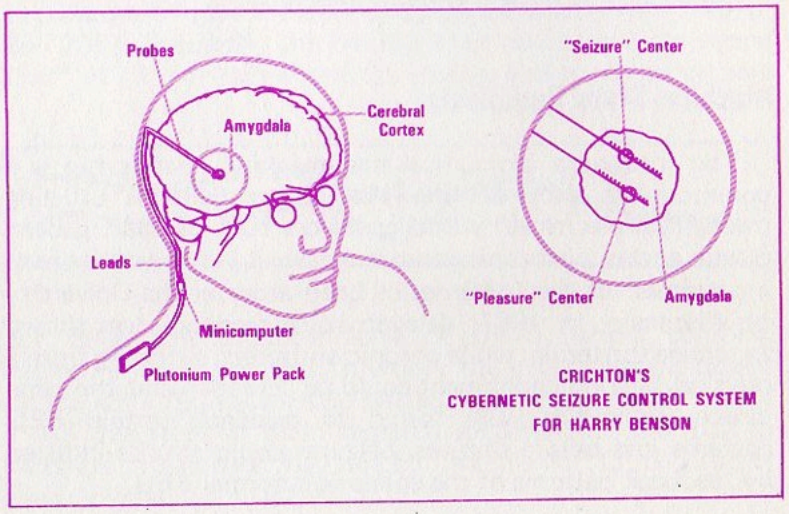
> *What is required to fit the facts, therefore, is not a theory that assigns a tiny bit of consciousness to every atom of matter. It does not even appear that consciousness is an inevitable property of complex computing/logic-processing structures. Instead, the evidence suggests that the property or consciousness is possessed only by very special organizations of matter (of types yet to be determined) when placed in a suitable electrochemical state (that is still unknown).*

Machine-Brain Symbiosis

The idea of a biomedical man-machine relationship is a commonplace fact of life. Modern medicine is utilizing mechanical/electrical/hydraulic devices such as heart pacers, plastic aortas, electronic sensors and steel joints with increasing success. At the Cybernetics Laboratory at the University of Wisconsin, in 1967, delayed voice feedback was shown to induce stuttering, while chronic stutterers, suffering from a physical hearing impairment could be "cured" using the same device. Epileptics were found to evidence certain EEG patterns just before seizures. Seizures could also be induced by feedback patterns of the epileptic's normal EEG.

Michael Crichton, in his recently published novel, *The Terminal Man,* has taken these developments to their logical conclusion—the linking of a small portion of a Man's brain to the control of a computer. Of course, things go haywire, just as they sometimes have in animal experiments. What Crichton is really suggesting is that we have the knowledge, technology, and surgical procedure to attempt such a symbiosis. The idea is certainly no more diabolical than the lobotomies and shock treatments of the past.

Harry Benson, Crichton's "terminal man," is a psychomotor epileptic (with psychotic tendencies) who has violent seizures. Before each seizure he would experience strange smells, then black out during the period of violence of the seizure. An operation placed a postage stamp-sized minicomputer in his neck, two probes with an array of twenty sensor-stimulator points deep in his brain (in the pea-sized Amygdala), and a plutonium power pack in his shoulder. These devices were linked by fine leads just under the skin. The minicomputer was capable of radio control by the hospital's IBM 360; this feature was necessary for starting the system operation. A cybernetic system for controlling Harry's seizures was thus set up. As soon as Harry would start to smell strange odors, the sensors on the probes in his brain would send a "warning" to the minicomputer, which in turn would send a stimulus to a "pleasure center" in the Amygdala, thwarting the seizure (2).



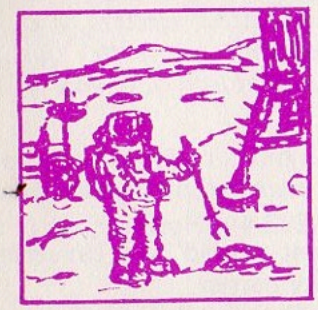
CRICHTON'S
CYBERNETIC SEIZURE CONTROL SYSTEM
FOR HARRY BENSON

A New Kind of Evolution

What all this speculation has been leading to has been proposed by writers of science and fiction alike. As Isaac Asimov puts it: (5, p. 68-9)

All these attempts to mimic the mind of Man are in their earliest infancy. Not in the foreseeable future can we envision any possibility of a machine matching the human brain. The road, however, is open. It conjures up thoughts which are exciting but also, in some ways, frightening. What if man eventually were to produce a mechanical creature equal or superior to himself in all respects, including intelligence and creativity? Would it replace man, as the superior organisms of the Earth have replaced or subordinated the less well adapted in the long history of evolution?

It is a queasy thought: that we represent, for the first time in the history of life on the Earth, a species capable of bringing about its own replacement. Of course, we have it in our power to prevent such a regrettable denouement by refusing to build machines that are too intelligent. It is tempting to build them nevertheless. What achievement could be grander than the creation of an object that surpasses the creator? How could we consummate the victory of intelligence over Nature more gloriously than by passing on our heritage, in triumph, to a greater intelligence—of our own making.



Arthur C. Clarke thinks that such a conclusion is inevitable, and that humans are essential in the cosmic plan: (1, p. 273-4)

. . .the brain is a lousy computer. Nevertheless, the biological system is the only way you can get from a lifeless planet to an electronic intelligence. I can't imagine all the metals in a dead planet organizing themselves eventually into an IBM computer. I think they've got to pass through something like us, and this is our role in the evolutionary sequence. We are a transitional stage in the development of a high-powered swift intelligence that is probably going to be electronic and that probably won't live on the planets at all. It may live either in space or, as I suggested, in the real centers of energy in the Universe, where there are tremendous quantities of radiation and electronic activity. The first generation of electronic intelligences, which lies only a few years ahead of us if it's not already here will be based on matter. There'll be printed circuits and electrons moving through wires and so forth, but ultimately we may get away from that into pure energy fields.

Clarke is overlooking (or going beyond) one of Wooldridge's basic positions: that machine intelligence does not have to be electronic (3, p. 232-4). However, it is a plausible way for intelligence to "get around" the Universe, given the speed of light/matter-engery barrier.

What we have left is "The Last Question"; Isaac Asimov wrote about it in 1956 (5, p. 69-84). You might like to read this short story yourself to see if you can find the answer.

THE LIVING COMPUTER

This is the computer's day
The computer is here to stay
Only temporarily
For yesterday's 360
Is a 370 today
Tomorrow the World?
1st, 2nd, 3rd generation
No need for renumeration
To make man obsolete
The optimum goal
Won't save his station
Learn to love
Your friendly computer
For he may be
A big help someday
Already, we can't do without him
The computer? He's alive and well
Solving the problem
Man? He's there somewhere too
Creating problems,
Loving, living, and
Dying

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RWH

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