The Mind

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Is the mind a machine? If it is and if we could build one, then we would have man-made objects that could think like people do. Their joining us as sentient beings would pose profound societal and philosophical questions. "Is the mind a machine?" is therefore a very special kind of question.

Scientists and philosophers have wrestled with the nature of the mind from the time people first suspected they had one. Now a new generation of scientists, those trying to build devices that can perceive, reason, and act autonomously, are helping to pose the question in sharper terms. They suppose that the answer is "Yes, the mind is a physical machine," partly because of their enlarged understanding of what a machine can be and partly because they find it difficult to imagine what it would be like for the mind *not* to be a machine. The word *machine,* of course, no longer brings to mind stolid assemblies of clanking gears and wheels. Our new views of protein-building RNA and ribosomal machinery, the machinery of neural circuits in living animals, and complex hardware/software combinations in digital computing machines make the phrase *mere machine* an anachronism.

For those of us who accept that the mind is, after all, mechanical, there are numerous other questions that divide us. We ask, "Can we ever *build* a mind?" Some think that the mind, although physical, will never be understood so thoroughly that engineers will be able to build one. The mind, these people say, is like the weather—physical, yes, but never *completely* explainable or predictable. Whatever processes may go on inside the human brain to produce thinking, feeling, creative expression, love, and so on, these processes are just too complicated for us ever to understand or to build into machines. Others of us who are more optimistic (some might say pessimistic) think that people *will* someday be able to understand the mind well enough to engineer mind-like mechanisms. For us, a more specific question arises: Can we understand the functions of the mind completely in terms of the operations that occur in digital computers, namely, abstract operations on symbols? Viewed from the perspective of computer science, computers do nothing more than rearrange complex assemblages of symbols—numerals, alphabetic characters, and such—according to well-specified rules. Is the mind a "symbol processor"?

People who think the answer to these questions is yes accept what is called the *physical symbol-system hypothesis.* This is a very important scientific hypoth-esis—just as were those of Copernicus and Darwin. Although these latter theories have now been largely confirmed, the symbol-system hypothesis is still really just a question—not yet an answer.

In fact, some scientists and philosophers think that other physical processes like holography, which is only approximately achievable by symbol-processing opera-tions, are necessary for mind-like qualities. Others think that as-yet-undiscovered biological properties of protein might somehow be necessary to the functioning of the mind.

One important consequence of accepting the symbol-system hypothesis is that *it wouldn't matter* what material a mind is made of. All that matters is that symbols be processed by a machine made of *some* material; whether it is protein or silicon or something else is completely irrelevant. Therefore, if the symbol-system hypothesis is true, the question "How does a neuron work?" is no more important for understanding the mind than the question "How does a transistor work?" is for understanding a computer-based airline reservation system.

Let's assume for a moment that the symbol-system hypothesis is true. There are still further questions, such as, "How is *knowledge* represented in the mind?" and "How should it be represented in computers?" Many psychologists believe that humans and perhaps some other animals have two different kinds of knowledge: a kind that can be expressed in *declarative* sentences (e.g., males do not get pregnant) and a kind represented by automatic *procedures* (e.g., duck when a rock whizzes by your head).

Researchers in artificial intelligence (AI) use declarative sentences in special computer languages to give facts to "expert systems" programs that are able to solve reasoning problems in medical diagnosis, financial management, chemical analysis, and the like. One powerful advantage of declarative knowledge over the procedural kind is that declarative knowledge can be used in many ways—ways perhaps not envisioned by the machine's original designer. Humans seem to use both kinds of knowledge, and so will intelligent machines, but AI researchers still argue about the relative merits and the roles of each.

Another question is, "Can we use what psychologists already know about how the brain works to help us build smarter machines?" Many AI researchers (perhaps immodestly) think a better question is, "Will we be better able to understand how the brain works using the concepts invented by AI scientists?"

A yes answer to this latter question assumes that it is not the lack of additional experiments by the psychologists and neurophysiologists that keeps us in the dark about the mind. What we lack are the *concepts* that will form the building blocks of understanding. It is important to note that concepts are *invented,* not *discovered.* (Edison invented the light bulb; Columbus discovered America.) The challenge of building intelligent machines is likely to stimulate the invention of these necessary concepts.

Curiosity about the mind, and our recent attempts to build primitive mind-like mechanisms, have provoked some of the most compelling and deep questions humans have ever asked. I suspect we will have to ask many more before answers start coming in.