Is the Brain's Mind a Computer Program?

No. A program merely manipulates symbols, whereas a brain attaches meaning to them

by John R. Searle

Can a machine think? Can a machine have conscious thoughts in exactly the same sense that you and I have? If by "machine" one means a physical system capable of performing certain functions (and what else can one mean?), then humans are machines of a special biological kind, and humans can think, and so of course machines can think. And, for all we know, it might be possible to produce a thinking machine out of different materials altogether—say, out of silicon chips or vacuum tubes. Maybe it will turn out to be impossible, but we certainly do not know that yet.

In recent decades, however, the question of whether a machine can think has been given a different interpretation entirely. The question that has been posed in its place is, Could a machine think just by virtue of implementing a computer program? Is the program by itself constitutive of thinking? This is a completely different question because it is not about the physical, causal properties of actual or possible physical systems but rather about the abstract, computational properties of formal computer programs that can be implemented in any sort of substance at all, provided only that the substance is able to carry the program.

A fair number of researchers in artificial intelligence (AI) believe the answer to the second question is yes; that is, they believe that by designing the right programs with the right inputs and outputs, they are literally creating minds. They believe furthermore that they have a scientific test for determining success or failure: the Turing test devised by Alan M. Turing, the founding father of artificial intelligence. The Turing test, as currently understood, is simply this: if a computer can perform in such a way that an expert cannot distinguish its performance from that of a human who has a certain cognitive ability—say, the ability to do addition or to understand Chinese—then the computer also has that ability. So the goal is to design programs that will simulate human cognition in such a way as to pass the Turing test. What is more, such a program would not merely be a model of the mind; it would literally be a mind, in the same sense that a human mind is a mind.

By no means does every worker in artificial intelligence accept so extreme a view. A more cautious approach is to think of computer models as being useful in studying the mind in the same way that they are useful in studying the weather, economics or molecular biology. To distinguish these two approaches, I call the first strong AI and the second weak AI. It is important to see just how bold an approach strong AI is. Strong AI claims that thinking is merely the manipulation of formal symbols, and that is exactly what the computer does: manipulate formal symbols. This view is often summarized by saying, "The mind is to the brain as the program is to the hardware."

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Strong AI is unusual among theories of the mind in at least two respects: it can be stated clearly, and it admits of a simple and decisive refutation. The refutation is one that any person can try for himself or herself. Here is how it goes. Consider a language you don't understand. In my case, I do not understand Chinese. To me Chinese writing looks like so many meaningless squiggles. Now suppose I am placed in a room containing baskets full of Chinese symbols. Suppose also that I am given a rule book in English for matching Chinese symbols with other Chinese symbols. The rules identify the symbols entirely by their shapes and do not require that I understand any of them. The rules might say such things as, "Take a squiggle-squiggle sign from basket number one and put it next to a squoggle-squoggle sign from basket number two."

Imagine that people outside the room who understand Chinese hand in small bunches of symbols and that in response I manipulate the symbols according to the rule book and hand back more small bunches of symbols. Now, the rule book is the "computer program." The people who wrote it are "programmers," and I am the "computer." The baskets full of symbols are the "data base," the small bunches that are handed in to me are "questions" and the bunches I then hand out are "answers."

Now suppose that the rule book is written in such a way that my "answers" to the "questions" are indistinguishable from those of a native Chinese speaker. For example, the people outside might hand me some symbols that unknown to me mean, "What's your favorite color?" and I might after going through the rules give back symbols that, also unknown to me, mean, "My favorite is blue, but I also like green a lot." I satisfy the Turing test for understanding Chinese. All the same, I am totally ignorant of Chinese. And there is no way I could come to understand Chinese in the system as described, since there is no way that I can learn the meanings of any of the symbols. Like a computer, I manipulate symbols, but I attach no meaning to the symbols.

The point of the thought experiment is this: if I do not understand Chinese solely on the basis of running a computer program for understanding Chinese, then neither does any other digital computer solely on that basis. Digital computers merely manipulate formal symbols according to rules in the program.

What goes for Chinese goes for other forms of cognition as well. Just manipulating the symbols is not by itself enough to guarantee cognition, perception, understanding, thinking and so forth. And since computers, qua computers, are symbol-manipulating devices, merely running the computer program is not enough to guarantee cognition.

This simple argument is decisive against the claims of strong AI. The first premise of the argument simply states the formal character of a computer program. Programs are defined in terms of symbol manipulations, and the symbols are purely formal, or "syntactic." The formal character of the program, by the way, is what makes computers so powerful. The same program can be run on an indefinite variety of hardwares, and one hardware system can run an indefinite range of computer programs. Let me abbreviate this "axiom" as

Axiom 1. *Computer programs are formal (syntactic).*

This point is so crucial that it is worth explaining in more detail. A digital computer processes information by first encoding it in the symbolism that the computer uses and then manipulating the symbols through a set of precisely stated rules. These rules constitute the program. For example, in Turing's early theory of computers, the symbols were simply 0's and 1's, and the rules of the program said such things as, "Print a 0 on the tape, move one square to the left and erase a 1." The astonishing thing about computers is that any information that can be stated in a language can be encoded in such a system, and any information-processing task that can be solved by explicit rules can be programmed.

Two further points are important. First, symbols and programs are purely abstract notions: they have no essential physical properties to define them and can be implemented in any physical medium whatsoever. The 0's and 1's, qua symbols, have no essential physical properties and a fortiori have no physical, causal properties. I emphasize this point because it is tempting to identify computers with some specific technology—say, silicon chips—and to think that the issues are about the physics of silicon chips or to think that syntax identifies some physical phenomenon that might have as yet unknown causal powers, in the way that actual physical phenomena such as electromagnetic radiation or hydrogen atoms have physical, causal properties. The second point is that symbols are manipulated without reference to any meanings. The symbols of the program can stand for anything the programmer or user wants. In this sense the program has syntax but no semantics.

The next axiom is just a reminder of the obvious fact that thoughts, perceptions, understandings and so forth have a mental content. By virtue of their content they can be about objects and states of affairs in the world. If the content involves language, there will be syntax in addition to semantics, but linguistic understanding requires at least a semantic framework. If, for example, I am thinking about the last presidential election, certain words will go through my mind, but the words are about the election only because I attach specific meanings to these words, in accordance with my knowledge of English. In this respect they are unlike Chinese symbols for me. Let me abbreviate this axiom as

Axiom 2. *Human minds have mental contents (semantics).*

Now let me add the point that the Chinese room demonstrated. Having the symbols by themselves—just having the syntax—is not sufficient for having the semantics. Merely manipulating symbols is not enough to guarantee knowledge of what they mean. I shall abbreviate this as

Axiom 3. *Syntax by itself is neither constitutive of nor sufficient for semantics.*

At one level this principle is true by definition. One might, of course, define the terms syntax and semantics differently. The point is that there is a distinction between formal elements, which have no intrinsic meaning or content, and those phenomena that have intrinsic content. From these premises it follows that

Conclusion 1. *Programs are neither constitutive of nor sufficient for minds.*

And that is just another way of saying that strong AI is false.

It is important to see what is proved and not proved by this argument.

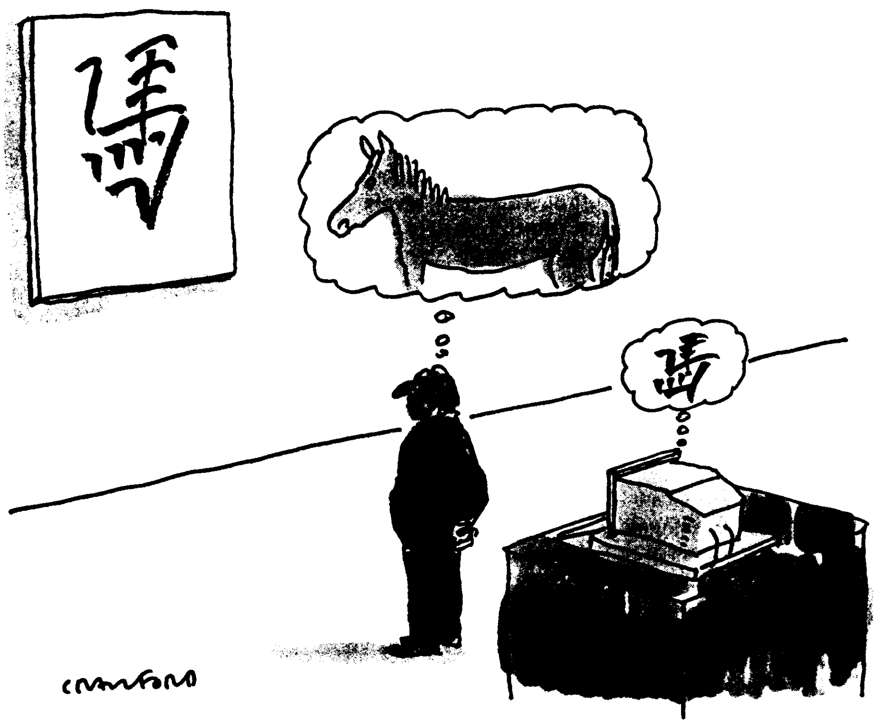
First, I have not tried to prove that "a computer cannot think." Since anything that can be simulated computationally can be described as a computer, and since our brains can at some levels be simulated, it follows trivially that our brains are computers and they can certainly think. But from the fact that a system can be simulated by symbol manipulation and the fact that it is thinking, it does not follow that thinking is equivalent to formal symbol manipulation.

Second, I have not tried to show that only biologically based systems like our brains can think. Right now those are the only systems we know for a fact can think, but we might find other systems in the universe that can produce conscious thoughts, and we might even come to be able to create thinking systems artificially. I regard this issue as up for grabs.

Third, strong AI's thesis is not that, for all we know, computers with the right programs might be thinking, that they might have some as yet undetected psychological properties; rather it is that they must be thinking because that is all there is to thinking.

Fourth, I have tried to refute strong AI so defined. I have tried to demonstrate that the program by itself is not constitutive of thinking because the program is purely a matter of formal symbol manipulation—and we know independently that symbol manipulations by themselves are not sufficient to guarantee the presence of mean-

I satisfy the Turing test for understanding Chinese



Computer programs are formal (syntactic).
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ings. That is the principle on which the Chinese room argument works.

I emphasize these points here partly because it seems to me the Churchlands [see "Could a Machine Think?" by Paul M. Churchland and Patricia Smith Churchland, page 32] have not quite understood the issues. They think that strong AI is claiming that computers might turn out to think and that I am denying this possibility on commonsense grounds. But that is not the claim of strong AI, and my argument against it has nothing to do with common sense.

I will have more to say about their objections later. Meanwhile I should point out that, contrary to what the Churchlands suggest, the Chinese room argument also refutes any strong-AI claims made for the new parallel technologies that are inspired by and modeled on neural networks. Unlike the traditional von Neumann computer, which proceeds in a step-by-step fashion, these systems have many computational elements that operate in parallel and interact with one another according to rules inspired by neurobiology. Although the results are still modest, these "parallel distributed processing," or "connectionist," models raise useful questions about how complex, parallel network systems like those in brains might actually function in the production of intelligent behavior.

The parallel, "brainlike" character of the processing, however, is irrelevant to the purely computational aspects of the process. Any function that can be computed on a parallel machine can also be computed on a serial machine. Indeed, because parallel machines are still rare, connectionist programs are usually run on traditional serial machines. Parallel processing, then, does not afford a way around the Chinese room argument.

What is more, the connectionist system is subject even on its own terms to a variant of the objection presented by the original Chinese room argument. Imagine that instead of a Chinese room, I have a Chinese gym: a hall containing many monolingual, English-speaking men. These men would carry out the same operations as the nodes and synapses in a connectionist architecture as described by the Churchlands, and the outcome would be the same as having one man manipulate symbols according to a rule book. No one in the gym speaks a word of Chinese, and there is no way for the system as a whole to learn the meanings of any Chinese words. Yet with appropriate adjustments, the system could give the correct answers to Chinese questions.

There are, as I suggested earlier, interesting properties of connectionist nets that enable them to simulate brain processes more accurately than traditional serial architecture does. But the advantages of parallel architecture for weak AI are quite irrelevant to the issues between the Chinese room argument and strong AI.

The Churchlands miss this point when they say that a big enough Chinese gym might have higher-level mental features that emerge from the size and complexity of the system, just as whole brains have mental features that are not had by individual neurons. That is, of course, a possibility, but it has nothing to do with computation. Computationally, serial and parallel systems are equivalent: any computation that can be done in parallel can be done in serial. If the man in the Chinese room is computationally equivalent to both, then if he does not understand Chinese solely by virtue of doing the computations, neither do they. The Churchlands are correct in saying that the original Chinese room argument was designed with traditional AI in mind but wrong in thinking that connectionism is immune to the argument. It applies to any computational system. You can't get semantically loaded thought contents from formal computations alone, whether they are done in serial or in parallel; that is why the Chinese room argument refutes strong AI in any form.

Many people who are impressed by this argument are nonetheless puzzled about the differences between people and computers. If humans are, at least in a trivial sense, computers, and if humans have a semantics, then why couldn't we give semantics to other computers? Why couldn't we program a Vax or a Cray so that it too would have thoughts and feelings? Or why couldn't some new computer technology overcome the gulf between form and content, between syntax and semantics? What, in fact, are the differences between animal brains and computer systems that enable the Chinese room argument to work against computers but not against brains?

The most obvious difference is that the processes that define something as a computer—computational processes—are completely independent of any reference to a specific type of hardware implementation. One could in principle make a computer out of old beer cans strung together with wires and powered by windmills.

But when it comes to brains, although science is largely ignorant of how brains function to produce mental states, one is struck by the extreme specificity of the anatomy and the physiology. Where some understanding exists of how brain processes produce mental phenomena—for example, pain, thirst, vision, smell—it is clear that specific neurobiological processes are involved. Thirst, at least of certain kinds, is caused by certain types of neuron firings in the hypothalamus, which in turn are caused by the action of a specific peptide, angiotensin II. The causation is from the "bottom up" in the sense that lower-level neuronal processes cause higher-level mental phenomena. Indeed, as far as we know, every "mental" event, ranging from feelings of thirst to thoughts of mathematical theorems and memories of childhood, is caused by specific neurons firing in specific neural architectures.

But why should this specificity matter? After all, neuron firings could be simulated on computers that had a completely different physics and chemistry from that of the brain. The answer is that the brain does not merely instantiate a formal pattern or program (it does that, too), but it also *causes* mental events by virtue of specific neurobiological processes. Brains are specific biological organs, and their specific biochemical properties enable them to cause consciousness and other sorts of mental phenomena. Computer simulations of brain processes provide models of the formal aspects of these processes. But the simulation should not be confused with duplication. The computational model of mental processes is no more real than the computational model of any other natural phenomenon.

One can imagine a computer simulation of the action of peptides in the hypothalamus that is accurate down to the last synapse. But equally one can imagine a computer simulation of the oxidation of hydrocarbons in a car engine or the action of digestive processes in a stomach when it is digesting pizza. And the simulation is no more the real thing in the case of the brain than it is in the case of the car or the stomach. Barring miracles, you could not run your car by doing a computer simulation of the oxidation of gasoline, and you could not digest pizza by running the program that simulates such digestion. It seems obvious that a simulation of cognition will similarly not produce the effects of the neurobiology of cognition.

All mental phenomena, then, are caused by neurophysiological processes in the brain. Hence,

Axiom 4. *Brains cause minds.*

In conjunction with my earlier derivation, I immediately derive, trivially,

Conclusion 2. *Any other system capable of causing minds would have to have causal powers (at least) equivalent to those of brains.*

This is like saying that if an electrical engine is to be able to run a car as fast as a gas engine, it must have (at least) an equivalent power output. This conclusion says nothing about the mechanisms. As a matter of fact, cognition is a biological phenomenon: mental states and processes are caused by brain processes. This does not imply that only a biological system could think, but it does imply that any alternative system, whether made of silicon, beer cans or whatever, would have to have the relevant causal capacities equivalent to those of brains. So now I can derive

Conclusion 3. *Any artifact that produced mental phenomena, any artificial brain, would have to be able to duplicate the specific causal powers of brains, and it could not do that just by running a formal program.*

Furthermore, I can derive an important conclusion about human brains:

Conclusion 4. *The way that human brains actually produce mental phenomena cannot be solely by virtue of running a computer program.*

I first presented the Chinese room parable in the pages of *Behavioral and Brain Sciences* in 1980, where it appeared, as is the practice of the journal, along with peer commentary, in this case, 26 commentaries. Frankly, I think the point it makes is rather obvious, but to my surprise the publication was followed by a further flood of objections that—more surprisingly—continues to the present day. The Chinese room argument clearly touched some sensitive nerve.

The thesis of strong AI is that any system whatsoever—whether it is made of beer cans, silicon chips or toilet paper—not only might have thoughts and feelings but *must* have thoughts and feelings, provided only that it implements the right program, with the right inputs and outputs. Now, that is a profoundly antibiological view, and one would think that people in AI would be glad to abandon it. Many of them, especially the younger generation, agree with me, but I am amazed at the number and vehemence of the defenders. Here are some of the common objections.

a. In the Chinese room you really do understand Chinese, even though you don't know it. It is, after all, possible to understand something without knowing that one understands it.

b. You don't understand Chinese, but there is an (unconscious) subsystem in you that does. It is, after all, possible to have unconscious mental states, and there is no reason why your understanding of Chinese should not be wholly unconscious.

c. You don't understand Chinese, but the whole room does. You are like a single neuron in the brain, and just as such a single neuron by itself cannot understand but only contributes to the understanding of the whole system, you don't understand, but the whole system does.

d. Semantics doesn't exist anyway; there is only syntax. It is a kind of prescientific illusion to suppose that there exist in the brain some mysterious "mental contents," "thought processes" or "semantics." All that exists in the brain is the same sort of syntactic symbol manipulation that

Which semantics is the system giving off now?

goes on in computers. Nothing more.

e. You are not really running the computer program—you only think you are. Once you have a conscious agent going through the steps of the program, it ceases to be a case of implementing a program at all.

f. Computers would have semantics and not just syntax if their inputs and outputs were put in appropriate causal relation to the rest of the world. Imagine that we put the computer into a robot, attached television cameras to the robot's head, installed transducers connecting the television messages to the computer and had the computer output operate the robot's arms and legs. Then the whole system would have a semantics.

g. If the program simulated the operation of the brain of a Chinese speaker, then it would understand Chinese. Suppose that we simulated the brain of a Chinese person at the level of neurons. Then surely such a system would understand Chinese as well as any Chinese person's brain.

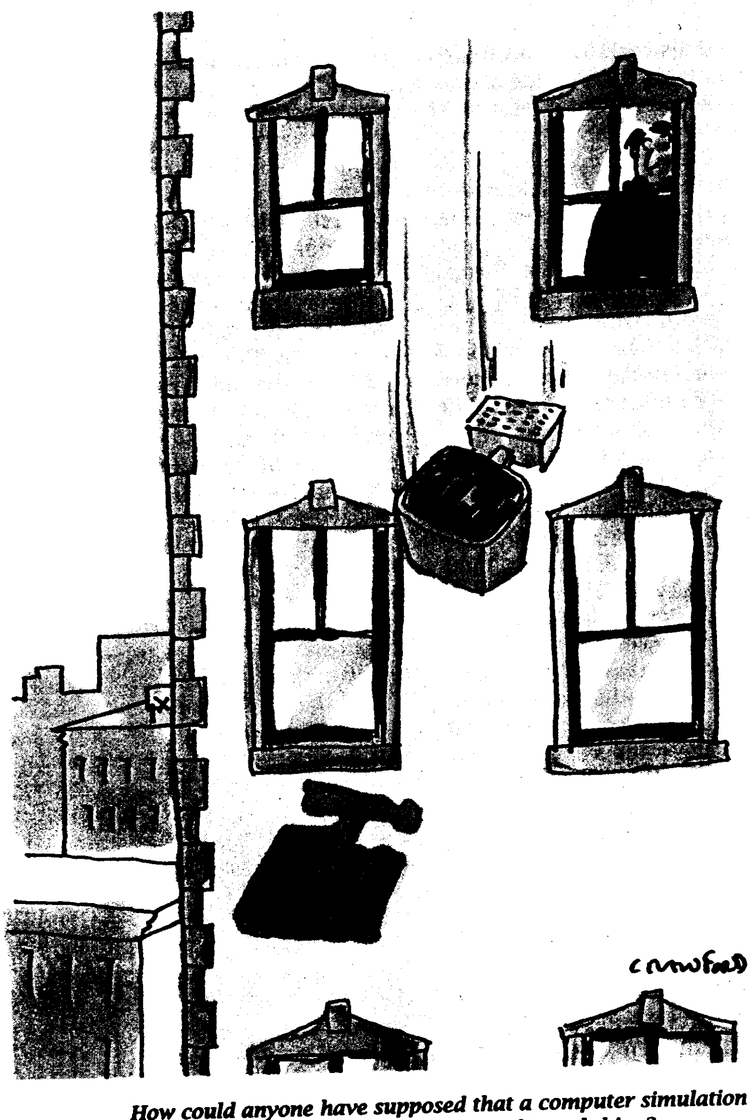
And so on.

All of these arguments share a common feature: they are all inadequate because they fail to come to grips with the actual Chinese room argument. That argument rests on the distinction between the formal symbol manipulation that is done by the computer and the mental contents biologically produced by the brain, a distinction I have abbreviated—I hope not misleadingly—as the distinction between syntax and semantics. I will not repeat my answers to all of these objections, but it will help to clarify the issues if I explain the weaknesses of the most widely held objection, argument c—what I call the systems reply. (The brain simulator reply, argument g, is another popular one, but I have already addressed that one in the previous section.)

The systems reply asserts that of course *you* don't understand Chinese but the whole system—you, the room, the rule book, the bushel baskets full of symbols—does. When I first heard this explanation, I asked one of its proponents, "Do you mean the room understands Chinese?" His answer was yes. It is a daring move, but aside from its implausibility, it will not work on purely logical grounds. The point of the original argument was that symbol shuffling by itself does not give any access to the meanings of the symbols. But this is as much true of the whole room as it is of the person inside. One can see this point by extending the thought experiment. Imagine that I memorize the contents of the baskets and the rule book, and I do all the calculations in my head. You can even imagine that I work out in the open. There is nothing in the "system" that is not in me, and since I don't understand Chinese, neither does the system.

The Churchlands in their companion piece produce a variant of the systems reply by imagining an amusing analogy. Suppose that someone said that light could not be electromagnetic because if you shake a bar magnet in a dark room, the system still will not give off visible light. Now, the Churchlands ask, is not the Chinese room argument just like that? Does it not merely say that if you shake Chinese symbols in a semantically dark room, they will not give off the light of Chinese understanding? But just as later investigation showed that light was entirely constituted by electromagnetic radiation, could not later investigation also show that semantics are entirely constituted of syntax? Is this not a question for further scientific investigation?

Arguments from analogy are notoriously weak, because before one can make the argument work, one has to establish that the two cases are truly analogous. And here I think they are not. The account of light in terms of electromagnetic radiation is a causal story right down to the ground. It is a causal account of the physics of electromagnetic radiation. But the analogy with formal symbols fails because formal symbols have no physical, causal powers. The only power that symbols have, qua symbols, is the power to cause the next step in the program when the machine is running. And there is no question of waiting on further research to reveal the physical,



How could anyone have supposed that a computer simulation of a mental process must be the real thing?

causal properties of 0's and 1's. The only relevant properties of 0's and 1's are abstract computational properties, and they are already well known.

The Churchlands complain that I am "begging the question" when I say that uninterpreted formal symbols are not identical to mental contents. Well, I certainly did not spend much time arguing for it, because I take it as a logical truth. As with any logical truth, one can quickly see that it is true, because one gets inconsistencies if one tries to imagine the converse. So let us try it. Suppose that in the Chinese room some undetectable Chinese thinking really is going on. What exactly is supposed to make the manipulation of the syntactic elements into specifically Chinese thought contents? Well, after all, I am assuming that the programmers were Chinese speakers, programming the system to process Chinese information.

Fine. But now imagine that as I am sitting in the Chinese room shuffling the Chinese symbols, I get bored with just shuffling the—to me—meaningless symbols. So, suppose that I decide to interpret the symbols as standing for moves in a chess game. Which semantics is the system giving off now? Is it giving off a Chinese semantics or a chess semantics, or both simultaneously? Suppose there is a third person looking in through the window, and she decides that the symbol manipulations can all be interpreted as stock-market predictions. And so on. There is no limit to the number of semantic interpretations that can be assigned to the symbols because, to repeat, the symbols are purely formal. They have no intrinsic semantics.

Is there any way to rescue the Churchlands' analogy from incoherence? I said above that formal symbols do not have causal properties. But of course the program will always be implemented in some hardware or another, and the hardware will have specific physical, causal powers. And any real computer will give off various phenomena. My computers, for example, give off heat, and they make a humming noise and sometimes crunching sounds. So is there some logically compelling reason why they could not also give off consciousness? No. Scientifically, the idea is out of the question, but it is not something the Chinese room argument is supposed to refute, and it is not something that an adherent of strong AI would wish to defend, because any such giving off would have to derive from the physical features of the implementing medium. But the basic premise of strong AI is that the physical features of the implementing medium are totally irrelevant. What matters are programs, and programs are purely formal.

The Churchlands' analogy between syntax and electromagnetism, then, is confronted with a dilemma; either the syntax is construed purely formally in terms of its abstract mathematical properties, or it is not. If it is, then the analogy breaks down, because syntax so construed has no physical powers and hence no physical, causal powers. If, on the other hand, one is supposed to think in terms of the physics of the implementing medium, then there is indeed an analogy, but it is not one that is relevant to strong AI.

Because the points I have been making are rather obvious—syntax is not the same as semantics, brain processes cause mental phenomena—the question arises, How did we get into this mess? How could anyone have supposed that a computer simulation of a mental process must be the real thing? After all, the whole point of models is that they contain only certain features of the modeled domain and leave out the rest. No one expects to get wet in a pool filled with Ping-Pong-ball models of water molecules. So why would anyone think a computer model of thought processes would actually think?

Part of the answer is that people have inherited a residue of behaviorist psychological theories of the past generation. The Turing test enshrines the temptation to think that if something behaves as if it had certain mental processes, then it must actually have those mental processes. And this is part of the behaviorists' mistaken assumption that in order to be scientific, psychology must confine its study to externally observable behavior. Paradoxically, this residual behaviorism is tied to a residual dualism. Nobody thinks that a computer simulation of digestion would actually digest anything, but where cognition is concerned, people are willing to believe in such a miracle because they fail to recognize that the mind is just as much a biological phenomenon as digestion. The mind, they suppose, is something formal and abstract, not a part of the wet and slimy stuff in our heads. The polemical literature in AI usually contains attacks on something the authors call dualism, but what they fail to see is that they themselves display dualism in a strong form, for unless one accepts the idea that the mind is completely independent of the brain or of any other physically specific system, one could not possibly hope to create minds just by designing programs.

Historically, scientific developments in the West that have treated humans as just a part of the ordinary physical, biological order have often been opposed by various rearguard actions. Copernicus and Galileo were opposed because they denied that the earth was the center of the universe; Darwin was opposed because he claimed that humans had descended from the lower animals. It is best to see strong AI as one of the last gasps of this antiscientific tradition, for it denies that there is anything essentially physical and biological about the human mind. The mind according to strong AI is independent of the brain. It is a computer program and as such has no essential connection to any specific hardware.

Many people who have doubts about the psychological significance of AI think that computers might be able to understand Chinese and think about numbers but cannot do the crucially human things, namely—and then follows their favorite human specialty—falling in love, having a sense of humor, feeling the angst of postindustrial society under late capitalism, or whatever. But workers in AI complain—correctly—that this is a case of moving the goalposts. As soon as an AI simulation succeeds, it ceases to be of psychological importance. In this debate both sides fail to see the distinction between simulation and duplication. As far as simulation is concerned, there is no difficulty in programming my computer so that it prints out, "I love you, Suzy"; "Ha ha"; or "I am suffering the angst of postindustrial society under late capitalism." The important point is that simulation is not the same as duplication, and that fact holds as much import for thinking about arithmetic as it does for feeling angst. The point is not that the computer gets only to the 40-yard line and not all the way to the goal line. The computer doesn't even get started. It is not playing that game.

FURTHER READING

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