
On Mind, Brain, and Computers

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From the very dawn of thought, humans have had a deep desire to solve the mystery of the mind. The mind is said to be the agent of thought. It is therefore but natural and fit that it should itself become the subject of inquiry.

Humans wish to grasp their own nature, their essence: that which makes them different from other entities—both sentient and insentient—from beings, from automatons, from other machines. What is it that really makes for the difference? It is the ability to think consciously and reason deliberately that distinguishes humans from other forms of existence. This is what makes them unique.

That human beings are rational is a truism; the ability to reason formally and in an abstract manner seems to be completely lacking in all other living beings. There are certainly many other human capabilities, but the ability which most marks an individual out as truly human is this ability to think, deliberate upon, analyse and categorize facts, formulate ideas, and decide on a course of action. These are truly the results of a developed mind.

Before the advent of modern science there was a clear demarcation between the mind and the brain. This distinction has become blurred with the passage of time. But the study of the brain as a neural machine and the development of computers as automata have enabled us to make equally bold statements about both—about what could possibly be done by them and what limits are impossible for them to overstep. In the present article, we shall discuss the nature of mind vis-a-vis the brain and computers. Such a comparison presumes a general equivalence of brains and computers and models the brain as a huge biological computer, with perhaps consciousness added.

On Mind

What Is Mind?

Although the singular ability to think is generally attributed to the human mind—this is what is meant when we say that mind is the agent of thought—there is a lot of debate in the cognitive sciences on the nature of this term: does a separate entity termed ‘mind’ exist, or is this just a linguistic convenience, some brain functions being traditionally confused with mind? Though divided in its opinion, the scientific community generally prefers to think that mind may not exist as a separate entity. There are two reasons for this thinking: one, the principle of simplicity makes the mind a redundant entity if brain function can explain it, and two, there is no definite sensory proof for the existence of mind; we have instead only certain beliefs and mundane evidence that is circumstantial at best.

Vedanta, in its psychology, accepts the existence of mind as a separate material entity. Western philosophers and theologians, in contrast, believe that the mind, if it exists, is non-material. According to them, all that is material belongs to the physical body. The mind, on the other hand, is considered to be part and parcel of the soul, or even to be the soul itself; and it definitely has a non-material existence. But if we agree to this view of mind being non-material, then several problems crop up.

Why Mind Cannot Be Non-material

One problem, traceable to Greek psychology, science, and theatre is that of *deus ex machina*, God playing the machine, whereby a supernatural intervention saves a hopeless situation. But in the ultimate analysis only a machine can work on another machine. Thus, if

the mind is not itself a physical machine in one way or another, then it cannot in any way work on the body, which is undoubtedly a machine, to get sensible results.

Take, for instance, the mundane desire to stand up or sit down. When this desire arises in the mind, it can have no way to get transformed into a suitable action. How can a mind that is non-material, that is not physically linked to the body, drive it in any way to make it either stand up or sit down? By what means could it be tied to the body so as to be able to exercise its pull or push?

The second problem with mind being non-material is that it cannot then store anything of the nature of information. In nature, wherever any information is stored, it is always stored in two ways: as different states of physical entities, or as variations in their arrangement or spatial order. Now, if mind does not have any matter in it, then it naturally follows that it cannot contain any information of the nature of *samskaras* (past impressions), as it will always be in the same state, and there is no possible arrangement of matter or energy that one can think of in an immaterial object.

The third objection, which is raised by Vedanta, is that any non-material thing is without form. This makes a non-material mind either infinite in dimension or merely a single point. Both possibilities give rise to serious conceptual problems. There are very few 'really real' entities in the world which are either infinite or mere points. I can only think of two: time and space. There might be a few other such entities, but mind surely does not seem to be one of them.

What if Mind Is Material?

If mind is material, then we have a host of other related questions to answer. Can the mind have an existence separate from the body? How does it function? How is it formed? Of what material is it made? Why is it not observed when it comes out of the body? In which part of the body does it reside? How is it connected

with the brain, that is, how do thoughts translate into actions? To answer each of these questions, earnest and sincere scientific and philosophical inquiry is required. I very much doubt if there is even a semblance of unanimity on these issues as yet, even after several millennia of unbroken discussion.

Another extreme position is taken by empirical scientists. They are of the view that mind is just a function of the brain, that it does not have a separate existence, and that dies its ignoble death with the death of the body. Needless to say, Vedanta does not subscribe to this view, even though neither the hypothesis nor its converse has been proved in any scientific fashion. We shall touch upon this topic again in another section below.

Capabilities of Mind

Vedantic thinkers classify mental function into four basic categories: *samkalpa-vikalpa* (cogitation, in the mode of *manas*), *niscaya* (ascertainment or determination, in the *buddhi* mode), *ahamkara* (ego), and *smṛti* (memory as *citta*). Thus, apart from the faculty of thought, the mind is supposed to have a sense of identity, an ego or I-sense. Furthermore, it has the capacity for introspection, which computers are said not to have. In the case of the brain it is difficult to say whether it is able to introspect or not.

It is the contention of the artificial-intelligence community that the ability of one part of the brain to observe the thought processes of the rest can be termed introspection. Moreover, at most times, this ability manifests itself not as true self-observation from a detached (or outsider's) standpoint but as a sort of recollection of the past or as planning for the future.

Mind is also said to be a reservoir of *samskaras*, a technical term for inherent tendencies, which define human character, one's fate or destiny. According to Vedanta, the mind comes to possess these *samskaras* as a result of every good or evil action performed through the innumerable births that transmigrating living beings undergo. Sometimes the mind is also

said to be the sum total of all samskaras. When a person dies, the mind, as part of subtle body, takes these samskaras away with it in order to create a new body with the character of the original person at a suitable time. The fact that the mind is separated from the body at the time of death also makes the mind, along with the subtle body, an almost autonomous entity. It can have an existence independent of the body.

On Brain

What Is Brain?

Brain, in contrast to mind, is easier to explain. It is a living mass of neurons, interconnected by its many dendrites, passing signals from one nerve to the other all the time. Of course, believers in holistic science argue that the brain when taken as a 'whole' becomes something else, that it is more than the sum total of its neurons.

Interestingly, and this is just to counter naive holism, Sri Ramakrishna advocated judicious reductionism. One may recall his observations regarding how to have detachment through a reductionist analysis of the nature of sense objects. The Sankhya philosophy also refutes the possibility of *sat*, existence, emerging from *asat*, non-existence. Nothing extra comes out of a combination. This is in contrast to the Charvaka position where quantitative changes can have qualitative effects.

Capabilities of the Brain

The brain is exceptionally good at vision, audition, pattern matching, and speech recognition. It is also skilled at making run-of-the-mill generalizations. It is very curious that even though it is well known that any inductive inference based on a finite number of facts in a non-finite logical system (such as second-order formal logic) is surely no deductive logic, yet people are known to generalize on as much as a single fact!

Nevertheless, human brains are also exceptionally brilliant when it comes to constructing

models of reality. These models are obviously much more systematic than the world outside, which is but a jumble of objects and places, isolated facts, and unrelated incidents. The outside world is interpreted in the light of one's own model, which, for the brain that constructed it, corresponds to the outside world in its details.

It is to be understood that this model, since it is constructed by the brain, is not static. It is a dynamic model, and whenever a jarring event which cannot be explained by the existing model occurs in the external world, the model is systematically modified by the brain in such a way as to agree with the new (contradictory) fact.

In more than one way, brain process is similar to the trichotomy of *śabda* (the word), *artha* (the referent), and *jñāna* (knowledge). The model in the brain corresponds to the word, the external world to referent objects, and knowledge to the many interpretations of the model, or in other words, to the relation between the model and the objective world. It is worth noting that this is not a one-to-one relationship. This is why each person has his or her own personal model of the world and his or her own private interpretations of the events therein, no one model or interpretation being identical to another.

As a logical consequence of the discussion above, one question naturally arises. Are all brains equal in their capabilities? Do the brains of lower species have similar capabilities as those of *Homo sapiens*? Surprisingly, any brain is theoretically capable of doing as much as any other brain, only the brains of lower species do not have the necessary tools at their disposal. Their situation is similar to the case of a mentally challenged person who has neither a fine aesthetic sense nor the disposition to master the sciences.

Are Mind and Brain the Same?

According to Vedanta, anything other than the Self, which is considered real, is made of

matter, however subtle. In making this statement (and in all matters concerning matter), license must be provided to wave-particle duality and matter-energy conversion. Hence, mind, which is non-Self, is also made of matter. And as a matter of general agreement this material of the mind is taken to be subtle matter. The brain, on the other hand, is made of gross matter and is a part of the body. This is the chief difference between mind and brain.

Further, if the mind were just a function of the body, then we cannot explain with any clarity the four different states of mind: *jāgrat*, *svapna*, *susupti*, and *turiya*—the waking state, dream, deep sleep, and superconsciousness. For example, if the ego is the primary by-product of the workings of the brain, then what happens to it during deep sleep (when the brain is still working but the ego appears to be dissolved), and how does it suddenly resurface when one wakes up?

Interaction between Mind and Brain

A further problem is raised by the scientific-minded. Any stimulus requires that some energy be expended. Thus, for thinking, the mind requires some energy. Where does this energy come from? The mind must have some energy source of its own for its multifarious activities. If that be so, then there must also be transfer of energy from mind to brain all the time. This energy must surely be enough to excite at least one neuron, if not more. This makes the mind not so subtle after all.

Nevertheless, this natural interaction between the subtle and the gross does not create any difficulty for staunchly non-dualist Vedantins. The domain of *maya* is not always amenable to deductive logic, and moreover, no scientific system has been able to explain all known phenomena. According to Vedantins, the phenomenal world is a superimposition on the Self, and so does not affect the intrinsic nature of the latter. As a matter of fact, if in the future computers are shown to have intelligence, that would not detract from the Vedantic position,

for the mind, being material, is at par with any other material object in its potential.

Let us now make a bold leap into the symbiotic world of computers and brains. A few questions need to be articulated at the very beginning: Can a computer be intelligent? Is it capable of thought? Can it have emotions? Can it be moral or could it have a conscience? Can it be self-conscious?

On Computers

What Is a Computer?

The formal model of a computer is a Turing machine: 'a mathematical model of a hypothetical computing machine which can use a predefined set of rules to determine a result from a set of input variables'. It is provable that all computers presently known can be modelled on Turing machines. This is equivalent to saying, loosely, that given enough time and space a Turing machine can do anything that any present day computer can possibly do.

A Turing machine as a formal construct is very simple to understand. It can be depicted by a reading and writing tape-head moving on a beginningless and endless tape made of discrete cells which are either blank or have one of a finite set of symbols printed within. The head is controlled by a program which tells it to read each cell, rewrite its content and move to an adjacent cell, depending on the entry in the scanned cell and the internal state of the machine, which itself can be changed based on the data on the tape. Every part of the Turing machine is finite; it is the potentially unlimited amount of tape that gives it an unbounded storage space.

Clearly, a Turing machine models human computing ability in several ways. Our brain is finite, just as the control program for the head is finite. The processing, the program, and the information of states all have correspondence with the various aspects of human memory and thought process. Furthermore, in doing arithmetic one does not have to do the whole com-

putation in the mind. One can use paper and pen to note down the intermediate steps; and there is obviously no theoretical limit to the amount of paper and ink one can use. This corresponds to the beginningless and endless tape that the Turing machine uses.

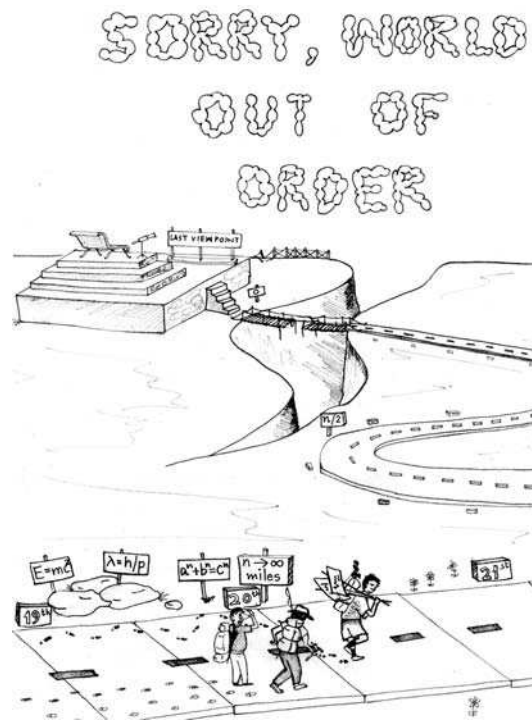
The Universal Turing Machine

Now there is an interesting corollary. The tape can also be thought of as some kind of memory. So the program controlling the head can also be written on the tape itself. This makes possible the construction of what is called the 'universal Turing machine'. This conceptual automaton need have only one program, which is capable of modifying itself to suit the needs of the problem under consideration. These problems can then be presented as other programs written as coded instructions on the tape. It can be shown mathematically that such a machine with only a single versatile program is capable of computing in exactly the same way as the earlier Turing machine. This leads to the important conclusion that all computers are inherently equal. Here we have a series of automata, constructed in a single pattern, but which can do a wide variety of tasks and have as varied a behaviour as possible.

What Is Artificial Intelligence?

Alan Turing (1912-54), who formalized mathematical computation, thus laying the foundation of modern computer science, was of the opinion that before the turn of the twentieth century computers would be able to think as humans think. But how can we know if a computer is thinking? Turing suggested a very simple test (called the Turing test) to ascertain if computers have 'real intelligence': Place the computer which is to be tested for intelligence in a closed room and place a person in another similar closed room. Now allow a tester, who does not know which room contains what, to ask questions of both and receive answers. This exchange, however, must be through a neutral transmission medium. The interrogator should

not get a clue to the identity of the replier from the medium of interaction (the person answering through a microphone and the computer



*'How far is it?'
Human Turing Machine—Miles to go...*

through a terminal, for instance). The human replier is expected to try to convince the judge through the answers given that he or she is really human, whereas the computer is to be so programmed that the judge cannot discern it to be a machine. To make matters more complicated, the computer is 'allowed' to give wrong answers similar to humans, feign ignorance, and also give delayed answers, giving the impression that it is thinking.

Turing himself suggested several objections that could be raised against this test; but all these objections can be adequately addressed. As matters stand, no computer till date has passed the Turing test satisfactorily, although there was an instance when a computer was able to successfully fool three judges out of a panel of five by wrongly answering some questions.

Capabilities of Computers

Computers are good at repetitive tasks. This is both their strength as well as their weakness. If you ask a computer to do a tediously monotonous task over and over again, it will keep on doing it without tiring or without ever following the 'human' way and doing things on its own. It does not undertake 'meta-thinking', that is, thinking as an outside observer or as a witness, as the mind does. Nor is it able to generalize and find out the general pattern of the task assigned to it as the brain readily does. However, computers are good at specialized tasks. If you give a computer a general rule and ask it to work out all the complex details, it will happily apply the rule to each and every special circumstance and get the required results.

Not surprisingly, as a result of their inability to generalize, computers are notoriously bad at pattern-matching. Within the time constraints allowed to them they can only do very basic analysis of speech and visual images. They can synthesize speech or images without much difficulty, but when it comes to analyzing speech and vision they have a very hard time doing it. On the other hand, computers can do arithmetic as no human can. A typical computer can add or multiply numbers consisting of tens of digits, at a rate of around a million operations per second. Moreover, computers can keep time with great accuracy. All their operations can be accomplished through a number of very accurately defined steps. Hence it is possible to ask computers to perform periodical tasks with great accuracy. A human being, in contrast, is forgetful and has to depend on external timepieces to know the time. It is very strange that despite its intricacy the brain has only a rudimentary sense of space and time.

Essential Differences between Computers and the Brain

The brain is a biological structure made of organic molecules, whereas computer chips are inorganic objects manufactured by etching circuits on the surface of silica chips. Thus the hu-

man brain, occupying volume, is a volumetric entity whereas a computer, as electronic circuitry on the surface of a silica chip, is an areal entity. This explains the vast processing power and exceptional capacities of the human brain.

Even though the human brain has got billions of neurons, each neuron has only a very basic processing power. Thus a brain can be thought of as a multiprocessor parallel computer where each processor is only capable of a few rudimentary operations, like checking if some signal is received or not. An average computer, on the other hand, consists of a single but powerful processing unit capable of doing hundreds of thousands of arithmetic computations in a fraction of second.

Is the Brain a Computer?

We have noted the architectural similarities between brains and computers. So is there really no difference between them? Are these two similar in all respects? Is the brain just a natural computer and a computer just an artificial brain?

Alan Turing is the co-proponent of another controversial thesis, the Church-Turing thesis, which states that anything that can possibly be computable physically, can be computed by a Turing machine. This has the far-reaching implication that the human brain may also be modelled on the Turing machine. Fortunately or unfortunately—depending on one's standpoint—no one has proved (or disproved) this hypothesis as yet. But it is a tribute to Church and Turing's genius that we have no better model for computation than a Turing machine till date.

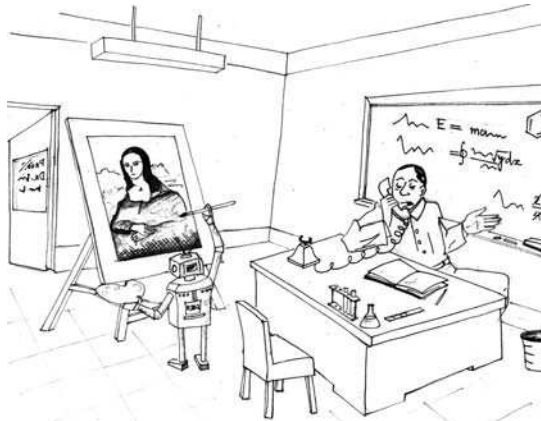
It is true that, as a consequence of Godel's famous 'incompleteness theorem', there exist true statements which cannot be proven either true or false in any logical system. It is also true, from Turing's equally famous 'halting problem', that there exist problems which cannot be solved by any algorithm (program) used by Turing machines. But the same can be said for the brain too, human or otherwise. There is not a

single theorem ever proved by any mathematician which is not potentially provable by a Turing Machine.

We might be tempted to say that it is humans who have proved the incompleteness of logical systems and are therefore superior to these systems. Detractors would argue that one system of logic can also prove the incompleteness of another logical system. Only if a brain can prove its own consistency after formalizing itself or handle infinite calculations in finite time can it be said to be superior to Turing machines, not otherwise.

Uniqueness of Consciousness

According to Vedanta, mind has an existence separate from the body. But we must be careful to note that it may not have any special abilities which pertain only to itself and which are not materially replicable. In fact, Mother Nature regularly replicates the mind-machine in one form or another. The only special or unique (*vilakṣaṇa*) entity posited by Vedanta is the Atman or Self, which is existence, knowledge, and bliss absolute. And this is unique to the Atman.



‘...but it insists on drawing portraits!’

If one were to contend that the light of the Atman is shining behind the mind then it can also be said that the same light is present behind computers. For the Upanishads say: ‘*Tameva*

bhāntam-anubhāti sarvaṁ, tasya bhāsā sarvam-idaṁ vibhāti; That shining, everything else shines; by that Light is lit up this objective world in its entirety.’ If we say that there is a difference in the intensity, that there is greater expression of this light in the mind than in gross matter, then this is exactly the point, there is only a difference in degree but not in kind.

Vedantic theory will not be challenged if in future computers come up with real intelligence, originality, or ‘brilliance’. Only a few years back it was thought that computers could not play chess, and now computers have decisively proved this wrong. The Vedantic model of the mind would however be shaken if evidence can be brought to show that the mind is but a shadow of brain function and that there is no transmigration of the mental apparatus.

Even though the mind is in all likelihood separate from the brain, it still seems logical to assume that it may not be in a position intrinsically superior to computers. This assertion, in all frankness, is open-ended. In all probability it is superior, but we may discover in the future that it is not quite so. For instance, it might be possible in future for computers to show practical intelligence and even to effectively simulate a personal identity or human emotions.

But does that in any way decrease the glory of the Atman that shines behind the mind? Not at all, for the Atman is ever the witness, ever the subject, transcending thought, intelligence, and emotions, and is consciousness itself. Thought, intelligence, and emotions are in the realm of maya and therefore within the purview of matter. If computers are material, so is the mind. Theoretically, there is nothing to stop computers from taking a quantum leap and developing themselves into something which is at par with the mental aspect of living beings. If the mind, despite being material, is capable of thought, as well as moral and aesthetic appreciation, then so could be computers in some foreseeable future. This much could be said for sure, given the lack of conclusive evidence to the contrary. *