

The Trotter Prize in Information, Complexity and Inference 2022

Lecture by Dean Emeritus Katepalli Sreenivasan

Sent by whom, flies out thither the mind?

I am honored to be part of the thirty-plus-year tradition of distinguished Trotter lectures, whose broader goal is to seek connections between two amazingly influential realms of human activity, Science and Religion. When my name gets inserted next year as a past recipient, it will appear one place away from Charlie Townes and two places away from Steven Weinberg, along with others such as Francis Crick, Freeman Dyson, Roger Penrose, and Bill Phillips, whom I have long admired; that's humbling.

I greatly appreciate the fact that Dr. and Mrs. Ida Trotter established this lectureship in honor of Dr. Trotter, Sr., who held a number of important positions at A&M. I enjoyed meeting the Trotter family at the dinner (and am honored to have them in the audience), but am also aware that Mr. Trotter, Jr. is severely unwell at the moment. I express my appreciation for his services to A&M, of which this lectureship is but one. I also wish to record my thanks to Professors Micah Green, Marlan Scully and Diego Donzis, and to Ms. Jennifer Holle for all the arrangements.

For context, I am a physical scientist attempting to understand the laws of the phenomenal world, having no pedigree in religion. My view is that, as science does not speak to the purpose of the universe, there is no reason why religion should not pursue its quest about God and Her will, morality, etc. These questions transcend humans but their impact is felt most at the human scale. To the extent that religion seeks to explain deep concepts, such as the relation of humans to a larger entity, via a system of beliefs and cultural cornucopia, I welcome it as an integral part of our collective thought-landscape. However, when religion is predicated on an exclusive God, Her special relationship with chosen groups of humans, and theories of miracles and afterlife, the concepts become too obfuscated to claim any real understanding on my part, despite the time and thought invested; and so I have little of consequence to say about them.

But I do have a few modest things to say on spirituality, which is quite different from religion--- though, of course, a link does exist. Spirituality is concerned with self-inquiry on the mystery of one's existence, seeking harmony between one's inner processes and the external world. This subject appeals to me personally because self-inquiry and contemplation, not revelation and authority, play a central role in this query.

Another pragmatic appeal is the empirically powerful role that spirituality plays in human life. Two people with different dispositions towards it react differently to the same turn of events. One sees greater connectedness in life than the other; one manages even vicious misfortunes admirably, the other succumbs to them; two people end up making different end-of-life decisions. In the Parable of the Second Arrow, the Buddha explains that we are all liable to encounter misfortunes anytime in our lives, because we mostly cannot control them, but our

response to those misfortunes is within our ability to shape. Pain is inevitable but suffering optional---and it can be mitigated by spiritual engagement.

Owing to physical, psychological, and social limitations, human life is linked with suffering or sorrow---as is emphasized, particularly but not exclusively, by Eastern religions, and so people attain their potential more fully by incorporating the spiritual realm, and developing a more optimistic and cosmically integrated view. This preponderant quest to assimilate spirituality in our lives makes the topic of today's discussion important---even if filtered through my personal inadequacies and limitations.

The key question is whether spirituality is an illusory creation of human mind. Or our efforts, rooted as they are in Matter, Forces, and here-and-now attitudes, fundamentally inadequate to comprehend it as a distinct and sublime entity. My goal is to present my thoughts in simple words, mostly my own; I regret that I cannot do better, partly because of the difficulty of the subject. Inevitably, I pay more attention to my own heritage (else, I wouldn't be genuine), but will strive to connect it with other aspects including science, at least as dimly as I understand them.

The title for today's talk comes from the Upanishad Kena, one of the dozen or so principal Upanishads, typically in the form of dialogues between students and teachers, which evocatively express the primordial urgings of spirituality. Kena, means By Whom, or Whence. Upanishads are conservatively dated between 1500 and 500 BCE, but scholars believe that they had existed for a lot longer, only codified around that time. Be that as it may, the question asked by the student is this, more fully: "Sent by whom, flies out thither the mind? Harnessed by whom, roves thither the first breath? Who sends out the speech which we speak? Who is it that harnesses the ears and eyes?" The student not asking the teacher to explain the physiology of vision or hearing apparatus etc., but is asking how the physical facts of a sensory input are transformed into personal experiences---such as the feelings of bliss, love and hurt, aroma of jasmine flowers, or the beauty of a majestic sunset.

The teacher's answer is that the insentient instruments---which are the eyes, the ears, the speech box, the mind, etc.---are rendered sentient by contact with one essential entity, which is beyond the physical body and the mind. That essential entity is the consciousness present in us. It is the consciousness that is at the very root of one's existence, unaffected by personality and ego, and the cause of awareness that gives meaning to the external world. It is the only principle that underlies all personal experiences, and includes our sensory and mental perception, but its true nature transcends all of them. It is the seer of everything that the senses and the mind touch. The pursuit of the true nature of consciousness is the highest spiritual quest. The teacher added, "Seeing this, the wise go forth from this world and become immortal." I will explain what he meant by immortal.

Advaita is one branch of philosophy among the several that developed from the Upanishads, and that's the one on which I shall focus. The word itself means non-dual, no-two, as I shall explain. I can obviously do no justice to a system of inquiry that has evolved over many centuries. For normal people, the individual consciousness is covered by a layer of ignorance about its own true nature. Once this layer of ignorance is wiped clean, Advaita claims the realization will dawn that the individual consciousness is one with the cosmic, universal consciousness, the latter being an irreducible, unitary, ever-present and immutable essence. It is not temporal. Not being in time, it does not undergo any change. Consciousness and Being are identical. There is no Becoming. Its appearance as temporal and multiple is a misperception. Space is one but appears as many because of limiting adjuncts, such as the walls of our homes. Likewise, the moon is one but its reflections in streams and lakes are many. Consciousness is the ultimate principle and nothing lies outside of it. Since an awakened consciousness in each of us is one with this cosmic consciousness, each of us is that same ultimate principle, which we often call divinity---once we experience this unity and shed our ego and its attributes completely; indeed, we are divine already but only need to shed the layer of ignorance to experience it. Gods and religions just evaporate merely as secondary.

If this universal pure consciousness is at once all pervasive and not subject to temporal and spatial dependencies, the question is how the multitudinous and variable universe is consistent with the unchanging principle. Advaita posits that they are but two manifestations of the same principle, just as energy and matter are two different forms of one entity. But it also states that the material universe that we observe has a lower level of reality, conditioned on its constraints (which we might call physical properties). These constraints render the material world mutable; impermanence is indeed a form of contradiction, and the truth is non-contradiction.

In this tradition, the ultimate spiritual quest is to experience the true nature of individual consciousness, which is the oneness with the cosmic consciousness. One is not asked to believe in this theory but urged to experience it directly. Advaita is thus not a mere philosophy, but an invitation to directly experience unity. As in science, one needs various preparatory steps, which are well laid out for millennia. There are four mutually reinforcing but different paths: the path of knowledge, the path of action, the path of devotion and the path of meditation. The important tool employed in these pursuits is one's mind, which has to be directed in the right way. By following these paths, or one of them that suits one's temperament best, one begins to know the eternal by waking to the realization that we, and everything around us, are in the eternal; indeed, the eternal is our real content.

The "immortality" that the teacher spoke about is the sense of liberation that occurs from the knowledge of one's unity with the larger principle. It is like the relief of a raindrop, assuming that it possesses a psyche of its own, which, layered by the ignorance of being all alone by itself, fears about disintegration as it falls into the sea. Instead of feeling separate and distinct, if it realizes that, in fact, it is one with the sea, as it always was, rendered separate from its true nature only by temporary conditions of heating by the sun, water vapor formation, nucleation and condensation of droplets, etc., there is complete liberation from anxiety, manifesting only the joy of unification with the ocean. In the same way, instead of tying individual consciousness to

the body and mind which are separate and undeniably decay with time, experiencing oneness with universal consciousness renders all limitations of body and mind irrelevant.

Advaita stipulates that brain is not the seat of consciousness, even though it plays a major role; that it is not possible to distill consciousness from matter, namely the brain. Consciousness, like electromagnetic waves (to choose a highly imperfect analogy) is all pervading, and human brain (like a radio station tuned to a particular wavelength) is better than anything else in biological existence to capture it. When one is awake, one experiences the physical world through senses and the mind which collect information; when one goes to sleep, the mind replays some of it from its storage, and the feeling is one of a very real experience; in that sense, dreaming is another form of waking, for dreams are replays that are unfiltered by the discrimination of the intellect (which is just the mind at a higher level). In deep sleep, the mind is at rest, and so is the body. There is plenty of low frequency activity in the brain but one is not aware of anything. Advaita says that consciousness is completely intact even in this state. Retrospective judgments such as "I slept well" are advanced to provide testimony to its existence.

The next qualitatively significant innovation in the theory of consciousness came from Buddhism. Buddha was not driven by the quest for self-realization or personal emancipation but by the compassion to end human suffering, which he viscerally perceived as universal. He started with the recognition that sorrow is real and that desire is the root cause of sorrow. As one desires more and more, one will encounter sorrow sooner or later, perhaps multiple times; more often than not, desires will become unfulfilled. Buddha traced the root of desire itself to be the sense of one's ego, or the "I", as in "I want this", "I am upset with that", "I did it", "I am not well", etc. What is this "I"? Upon inquiring as to where this "I" resides, he found that the search became ephemeral. He discovered the surprising result that it is through this non-existent "I" that we interact with every aspect of the world. If we realize that the source of this interaction, this insubstantial entity called "I", does not exist, we achieve what he called "shunyata" or the "null-state". This realization catapults one's inquiry into consciousness.

Buddhism seeks to eliminate the disparity between a person's view of reality and its actual state. Seeing reality as it exists is thus an essential prerequisite to our well-being. What is the nature of this reality? One of Buddha's fundamental teachings is that all the constituent forms that make up the universe are transient and therefore lacking in concreteness. This lack of enduring concreteness is an important corollary. Reality is ultimately a form of projection, resulting from the fruition of one's past deeds. Buddha laid out the eight-fold path by which people can develop awareness and come out of their state of suffering.

In the Buddhist concept, consciousness arises depending on certain conditions and is absent when these conditions subside. Human personality is nothing but a conglomeration of these ever-changing physical and mental formations. Being impermanent, these changes occur from moment to moment. Unlike in Advaita, consciousness is not eternal and self-existent (i.e., not dependent on the person who attains it) but a stream, and the objects that are taken to exist in

the external world are simply the images that appear in this stream. Consciousness is always evolving from the beginning. It continues to flow until one attains enlightenment by rooting out the stored seeds. Buddhism, like Advaita, emphasizes that an adequate answer to consciousness cannot be based on intellectual sophistication. The basic ingredient is direct experience, not theoretical learning.

To repeat: the essential difference between the Buddhist and the Advaitic views is that consciousness in Advaita is an eternal unchanging principle; that in Buddhism it is ever changing. In Advaita, the universe is a seamless whole and is connected in entirety---not in itself but because of the presence of the underlying absolute principle. In Buddhism, everything is made of discontinuous, discrete events; consciousness is a stream of individual thoughts and sensations. Even the flow of time is merely a stream of discontinuous moments. Buddhism has developed many later varieties, and great thinkers like Nagarjuna, who followed Buddha several centuries later, introduced many important modifications. Indeed, one finds the introduction of the notion of an absolute principle in some later forms of Buddhism.

Now we should ask: how much, if any, of these grand and ancient ideas is “true”? Is consciousness a mere result of a dynamic that can be explained by constituent parts via techniques of modern science? Is it simply an epiphenomenon that arises from electro-chemical mechanisms operating at the level of neurons, as well as their networking connectivity? After all, we have successfully explained, via science, eclipses, infectious diseases, and life itself, so why not also consciousness---perhaps as a particular emergent property arising from the complexity of the central nervous system, which may well go beyond its anatomical connections?

Research on consciousness is currently a serious scientific enterprise, which is slowly, and perhaps vaguely, coming to grips with the enormity of its potential. Thus, in terms of longevity, there is no other comparable topic; in terms of consequence to humanity as well, I know no other topic of equal importance. For, a deeper understanding of oneself allows one to reach the fullest potential, and to work towards a more enlightened society; it also has implications for the rights of the mentally impaired, people in coma and vegetative states, altered mind states by ingestion of legal and illegal drugs, animal rights, etc.

This research proceeds along a few obvious tenets---that the universe has no will of its own; that it simply exists, of which our known world is but a part; that living organisms, including the human body and the mind, are products of historical contingency based on evolution and consistent with the principles of physics, chemistry, and thermodynamics. Some researchers are optimistic that the tremendous advances being made in the understanding of the brain will one day unravel the mystery of consciousness as a by-product, known through the activity and adaptability of the brain.

However, research in this field is still controversial because the central paradigm has not yet been shaped; it is thus difficult to agree upon crucial and controlled experiments, which form the

bedrock of modern science. Accordingly, some researchers think that consciousness as a separate object of study is illusory, and that this epiphenomenon will eventually be reduced to the underlying cell biology, neuronal firing and networks; they think that, with the increasing power of computing and AI, we will reach a stage where it will be impossible to tell apart a machine from the human. Even those others who do not take this extreme position, debunk the idea that consciousness is an irreducible holistic substratum, which infuses the whole cosmos, even as it is rooted in causal power underlying one's personal experience.

But (nearly) everyone readily agrees that consciousness looks for integrated experiences and that we are far away from answering the following question: How can a physical system such as the brain generate first-person experience? How does one experience the color of a rose, the love for a poem, the rage at injustices, the enjoyment of a symphony, the beauty of the sunset, etc. This is a rough statement of the so-called hard problem of consciousness. One will, in due course, undoubtedly be able to obtain a deeper knowledge of the neuronal activity of the brain and correlate it with different sensory inputs (this being the easy problem), but the contention is that there will never be a time when a certain pattern in the firing of neurons can be understood causally in terms of first-person experiences.

One theory simply posits that consciousness is created by the information processing system contained in the brain, which also broadcasts it to other processing centers for subsequent action. Yet another theory states that the basic function of the brain is the cognitive processing of the sensory input, while consciousness arises as a next-order function. It is not clear that such a perturbative thinking works for the highly nonlinear system such as the brain. Another theory posits that consciousness is not to be associated with information processing but in the causal power to make decisions. I will add a few more words on this last-mentioned theory, called integrated information theory, mainly because of its characteristic of starting with the opposite end from others---namely, stipulating certain essential ingredients of consciousness, and then asking for physical mechanisms that can be held responsible for each of them. There is room for ambiguity in this approach, as in others, and, in some people's eyes, it invites derision as being "not even wrong". But it is astonishing that its conclusions are quite close to those of Advaita.

There are unresolved problems in experimental studies of consciousness. One way to explore it via wakeful states requiring meaningful reactions to solicited stimuli. However, the basic state of the brain is different for different people and the same stimulus will therefore generate different responses. There is much to be learnt from the study brain differences in different states of consciousness: sleep, anesthesia, drugs, vegetative states, coma, etc. A large part of the brain does not seem to take part in simulated tests of consciousness, which makes the connection between brain functions and consciousness quite difficult to evaluate. Behavioral criteria make it also difficult to assess the non-human aspects of consciousness: can we say with certainty that homing pigeons, elephants and whales do not possess consciousness (and how does one test that)?

Let's return to Advaita and Buddhism. The Buddhist tradition trains the mind to explore itself (it can certainly be done), and Advaita equally sees the need to train one's mind to go beyond itself. Both recognize the mind to be the an inevitable apparatus which, if used properly, can lead to higher levels of awareness. Mind, of course, is not the brain.

One cornerstone of both Advaita and Buddhism is that the material world is ill-defined and nebulous. Science in more recent years has uncovered many interesting aspects which give some credibility to this view. Relativity showed that there is, in fact, no absolute time and space. Whenever an object is deemed to have a certain mass or length, that mass or length is true only for that observation. Another observation at a different speed would give a different mass and length, and yet the two are equally true; we cannot consider one measurement to be true and the other deceptive. Likewise, the uncertainty principle says that when we measure the speed of a particle, we cannot know its position accurately; and when we measure the position, we cannot know the speed. This ambiguity is not just due to the clumsiness of our instruments, but holds true even for theoretical and mathematical calculations. This is because the particle by itself does not have an absolute form. We cannot identify a point of space or time where a particle exists; we can only give a probability of its existence at a certain point.

We thus have the situation in which the tiniest particles and the largest scales do not have absolute reality. Advaita and Buddhism go further and say this: If the world at the smallest scales is unreal, as it is at the largest scales, who is to say that it is real in the middle? They infer that the world at all scales is only a hazy reality. The world around us, although appearing for a first sight as solid deterministic reality, is in actual fact an undefined reality only. As science explores further and further, determinism—the root of reality of the world—seems to dissolve into unreality everywhere.

In Upanishads, the true and absolute reality is described as "not this, not this": i.e., no classical idea is sufficient or adequate to describe this reality. Buddha says: "Of this world, it cannot be said either that it 'exists,' 'not exists,' 'both exists and not exists' and 'neither exists nor not exists'"; and this conveys in a figurative sense the essential ambiguity of modern science.

In Advaita the claim is that the ultimate basis of the universe is a single, homogenous, continuous, absolute principle that is independent of time and space. Thus during meditation, when we introspect deeply into our consciousness and 'touch' the deepest level of our consciousness, we come into contact with this mystical experience of oneness.

Buddhism makes a different claim. At the deepest level, both the material world and our consciousness are discrete entities. Thus, introspection into the deepest layer of our consciousness shows that it is composed not of one single homogenous whole but of discrete parts; consciousness is a mere ensemble of disconnected pieces that give the appearance of a complete structure. An aspirant for truth can deconstruct his or her mind in this way and know that the structure that one observes is impermanent, thus undercutting the desires and all ensuing suffering.

The two hypotheses are compatible up to a point and diverge beyond. Perhaps we can go about providing an answer as to whether one of them is true, by subjecting them to the same scientific scrutiny that we know. We have to do so. In science, the standards of truth are set by logic and reason, and one condition of veracity is falsifiability. Thus, in the final analysis, if science achieves the final understanding of the universe, and finds the base of the universe to be a single homogenous absolute entity, the claim of Buddhism is falsified. If, on the other hand, something like the string theory in any of its versions, made of discrete objects, emerges as the final theory, then Advaita seems to be falsified.

There is a second point to be made. A central characteristic of modern science is its interconnectedness. If an edifice gets built with no tangible connections to any other branch of science, its viability is generally suspect. Science is not a dappled patchwork of laws with local validity. Likewise, if an Advaitin finds an ultimate truth that is vastly different from that of a Sufi Muslim or a Spiritual Christian, there is a problem. When one observes enlightened beings---not the managers of religious institutions who find it useful to maintain differences---they all find the truth of love and knowledge through direct personal experience within. This is especially true of the likes of our teacher of Kena, Aquinos, Buddha, Christ, Sankara, Ramakrishna, Vivekananda and Aurobindo. I feel confident that they were not deluding themselves.

Spiritual domain is not about the sophistication of one's knowledge; it is about elementary practices in one's life. The aim then is to enable human beings to solve the existential problems of life, transcend human limitations imposed by body, mind and intellect, go beyond suffering, and attain supreme fulfillment and peace. There are important steps arising from a combination of constant questioning, meditation, knowledge acquisition, and experiencing the ultimate goal.

Inquiring mind often begins with intuition. The recipe in the spiritual domain is that, having begun with intuition, to press forth with it instead of returning to rationality; one then unfolds a flame of light and a perceptive power, which is the pure consciousness that the teacher spoke about. By holding on to the knowledge we gain, we enable more ignorance to recede. In time we shall be all light. Maintaining the attitude of a witness, those with self-knowledge continually remember that they are not the body, not the mind. They know the inner consciousness is not subject to fatigue or anxiety or excitement; pure, perfect and free, it has no struggle to engage in, no further goals to attain.

One method of moving towards consciousness is self-distancing, or moving away from immediate sensory experience that one has just had, by becoming a witness to it. This is equivalent to a dialogue within, between one part of oneself and the other. The first major step is to acknowledge the existence of something beyond the human body, its senses, the brain, and the mind.

If, on the other hand, one remains oblivious to the oneness with universal consciousness and maintain the "I-ness" of being different from others, one will act out of impulse, division, anxiety

and a sense of separateness. The ultimate goal of an Advaitin's spiritual life is to transcend such limitations and free oneself from anger, excitement, greed, and hypocrisy. It becomes normal to always speak the truth, moderate one's practices, refrain from envy, forgive others and be gentle to them, and act with tranquility, courage, humility, benevolence and contentedness.

In both Buddhism and Advaita, every action and thought imprints on one's mind various levels of ego-laden existence. Since action is an integral part of being alive, we need to reorient our actions, not deny them. All of us tend to work with no expectations in mind. So much of our lives is run simply in expectation of future results that we do it automatically, unconsciously. This is a perilous pattern. From a spiritual viewpoint, all these expectations and anticipations bring us misery inevitably because they are, in the end, unappeasable. We will live from disappointment to disappointment because the motivation to gratify merely enlarges the ego.

For him who acts without desire, the execution of actions will serve the purpose of purification. The prescribed path is one of dedicated work: renouncing the results of our actions as a spiritual offering. Disengaging the ego from one's work is a way of liberating oneself. We then get to the state of sublimating our egos and free ourselves from the effects of our actions.

For me personally, consciousness has been an abiding interest since I was about ten, when my paternal grandfather occasionally had me read spiritual texts to him, as he listened with intense concentration, himself not wanting to be distracted by the act of reading. I have continued to think about the subject since. Yet, I had not dared to express anything at all in public so far (except some letters written to a friend as a teenager). Your kindness has brought me courage, but I should summarize.

Objects in the physical domain provide constant input to our senses. Senses not only include organs of sight, hearing, smell, and taste but also the electro-mechanical-optical instrumentation available to them. It always includes mind, which is regarded as part of the material world. The spiritual domain is primarily experiential and goes beyond the mind. In that climactic experience of realizing the true nature of oneself, the distinction between the knower and the objects to be known disappears. This is when one has "touched" pure consciousness.

In Advaita, the individual consciousness is also one with the irreducible cosmic consciousness that pervades the universe. Advaita posits that pure consciousness is one and non-dual. It is not the mere oneness of physical entity, which is a quest in physics, but the oneness of the underlying principle. The phenomenal world is indeed subject to constant change, and so has a lower level of reality. Advaita fully understands that humans are not the center of the universe, in terms of how miniscule they are in contrast to the vastness of the universe, but reinserts them as central because of the meaning they provide to the universe. The capacity to do so is consciousness.

Advaita has an important role in solving the individual and collective problems of day-to-day life. Advaitic knowledge can serve as the basis of morality, inner strength and courage; it serves as the basis of social justice as well because of the precept of “service to man is service to God”.

In modern scientific thinking, consciousness does not exist independent of the brain. If so, one has to be able somehow to extract a non-material principle out of the material object. We thus have a disconnect, But, it is exciting to see some lines of inquiry moving in the direction of Advaita and Buddhism. Further research may rule in favor of one or the other, or neither, but that situation is not yet clear.

No matter what precise position one takes, research on consciousness is a very important undertaking. Science has revealed to us many properties of *our* universe but has greatly lagged behind in deciphering our subjective experiences of it. This is the ultimate message of my talk. We have to change this. This realization has been responsible for the creation of several centers on consciousness (in places such as the University of Arizona, Sussex University, Harvard, University of Wisconsin, New York University, Allen Institute of Brain Sciences in Seattle, and many others). Various Foundations have been supporting these efforts. One can imagine that such an effort can be undertaken in this increasingly wonderful university as well. A productive activity in this area will link research on experimental and cognitive neuroscience, linguistics, complexity, fundamental physics, engineering, computations, AI, philosophy, religious studies, etc. I hope it will be possible. For me personally, it is the ultimate quest.