World Question Center

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"What Do You Believe Is True Even Though You Cannot Prove It?"

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Physicist and Nobel laureate, Princeton University

Is string theory a futile exercise as physics, as I believe it to be? It is an interesting mathematical specialty and has produced and will produce mathematics useful in other contexts, but it seems no more vital as mathematics than other areas of very abstract or specialized math, and doesn't on that basis justify the incredible amount of effort expended on it.

My belief is based on the fact that string theory is the first science in hundreds of years to be pursued in pre-Baconian fashion, without any adequate experimental guidance. It proposes that Nature is the way we would like it to be rather than the way we see it to be; and it is improbable that Nature thinks the same way we do.

The sad thing is that, as several young would-be theorists have explained to me, it is so highly developed that it is a full-time job just to keep up with it. That means that other avenues are not being explored by the bright, imaginative young people, and that alternative career paths are blocked.

STEPHEN KOSSLYN

Psychologist, Harvard University; Author, Wet Mind

Mental processes: An out-of-body existence?

These days, it seems obvious that the mind arises from the b rain (not the heart, liver, or some other organ). In fact, I personally have gone so far as to claim that "the mind is what the brain does." But this notion does not preclude an unconventional idea: Your mind may arise not simply from your own brain, but in part from the brains of other people.

Let me explain. This idea rests on three key observations.

The first is that our brains are limited, and so we use crutches to supplement and extend our abilities. For example, try to multiply 756 by 312 in your head. Difficult, right? You would be happier with a pencil and piece of paper—or, better yet, an electronic calculator. These devices serve as prosthetic systems, making up for cognitive deficiencies (just as a wooden leg would make up for a physical deficiency).

The second observation is that the major prosthetic system we use is other

people. We set up what I call "Social Prosthetic Systems" (SPSs), in which we rely on others to extend our reasoning abilities and to help us regulate and constructively employ our emotions. A good marriage may arise in part because two people can serve as effective SPSs for each other.

The third observation is that a key element of serving as a SPS is learning how best to help someone. Others who function as your SPSs adapt to your particular needs, desires and predilections. And the act of learning changes the brain. By becoming your SPS, a person literally lends you part of his or her brain!

In short, parts of other people's brains come to serve as extensions of your own brain. And if the mind is "what the brain does," then your mind in fact arises from the activity of not only your own brain, but those of your SPSs.

There are many implications of these ideas, ranging from reasons why we behave in certain ways toward others to foundations of ethics and even to religion. In fact, one could even argue that when your body dies, part of your mind may survive. But before getting into such dark and dusty corners, it would be nice to have firm footing—to collect evidence that these speculations are in fact worth taking seriously.

JOSEPH LEDOUX

Neuroscientist, New York University; Author, The Synaptic Self

For me, this is an easy question. I believe that animals have feelings and other states of consciousness, but neither I, nor anyone else, has been able to prove it. We can't even prove that other people are conscious, much less other animals. In the case of other people, though, we at least can have a little confidence since all people have brains with the same basic configurations. But as soon as we turn to other species and start asking questions about feelings, and consciousness in general, we are in risky territory because the hardware is different.

When a rat is in danger, it does things that many other animals do. That is, it either freezes, runs away or fights back. People pretty much do the same things. Some scientists say that because a rat and a person act the same in similar situations, they have the same kinds of subjective experiences. I don't think we can really say this.

There are two aspects of brain hardware that make it difficult for us to generalize from our personal subjective experiences to the experiences of other animals. One is the fact that the circuits most often associated with human consciousness involve the lateral prefrontal cortex (via its role in working memory and executive control functions). This broad zone is much more highly developed in people than in other primates, and whether it exists at all in non-primates is questionable. So certainly for those aspects of consciousness that depend on the prefrontal cortex, including aspects that allow us to know who we are and to make plans and decisions, there is reason to believe that even other primates might be different than people. The other aspect of the brain that differs dramatically is that humans have natural language. Because so much of human experience is tied up with language, consciousness is often said to depend on language. If so, then most other animals are ruled out of the consciousness game. But even if consciousness

doesn't depend on language, language certainly changes consciousness so that whatever consciousness another animal has it is likely to differ from most of our states of consciousness.

For these reasons, I think it is hard to know what consciousness might be like in another animal. If we can't measure it (because it is internal and subjective) and can't use our own experience to frame questions about it (because the hardware that makes it possible is different), it become difficult to study.

Most of what I have said applies mainly to the content of conscious experience. But there is another aspect of consciousness that is less problematic scientifically. It is possible to study the processes that make consciousness possible even if we can't study the content of consciousness in other animals. This is exactly what is done in studies of working memory in non-human primates. One approach by that has had some success in the area of conscious content in non-human primates has focused on a limited kind of consciousness, visual awareness. But this approach, by Koch and Crick, mainly gets at the neural correlates of consciousness rather than the causal mechanisms. The correlates and the mechanisms may be the same, but they may not. Interestingly, this approach also emphasizes the importance of prefrontal cortex in making visual awareness possible.

So what about feelings? My view is that a feeling is what happens when an emotion system, like the fear system, is active in a brain that can be aware of its own activities. That is, what we call "fear" is the mental state that we are in when the activity of the defense system of the brain (or the consequences of its activity, such as bodily responses) is what is occupying working memory. Viewed this way, feelings are strongly tied to those areas of the cortex that are fairly unique to primates and especially well developed in people. When you add natural language to the brain, in addition to getting fairly basic feelings you also get fine gradations due to the ability to use words and grammar to discriminate and categorize states and to attribute them not just to ourselves but to others.

There are other views about feelings. Damasio argues that feelings are due to more primitive activity in body sensing areas of the cortex and brainstem. Pankseep has a similar view, though he focuses more on the brainstem. Because this network has not changed much in the course of human evolution, it could therefore be involved in feelings that are shared across species. I don't object to this on theoretical grounds, but I don't think it can be proven because feelings can't be measured in other animals. Pankseep argues that if it looks like fear in rats and people, it probably feels like fear in both species. But how do you know that rats and people feel the same when they behave the same? A cockroach will escape from danger--does it, too, feel fear as it runs away? I don't think behavioral similarity is sufficient grounds for proving experiential similarity. Neural similarity helps—rats and people have similar brainstems, and a roach doesn't even have a brain. But is the brainstem responsible for feelings? Even if it were proven in people, how would you prove it in a rat?

So now we're back where we started. I think rats and other mammals, and maybe even roaches (who knows?), have feelings. But I don't know how to prove it. And because I have reason to think that their feelings might be different than ours, I prefer to study emotional behavior in rats rather than emotional feelings. I study rats because you can make progress at the neural

level, provided that the thing you measure is the same in rats and people. I wouldn't study language and consciousness in rats, so I don't study feelings either, because I don't know that they exist. I may be accused of being short-sighted for this, but I'd rather make progress on something I can study in rats than beat my head against the consciousness wall in these creatures.

There's lots to learn about emotion through rats that can help people with emotional disorders. And there's lots we can learn about feelings from studying humans, especially now that we have powerful function imaging techniques. I'm not a radical behaviorist. I'm just a practical emotionalist.

NEIL GERSHENFELD

Physicist, MIT; Author, When Things Start to Think

What do you believe is true even though you cannot prove it?

Progress.

The enterprise that employs me, seeking to understand and apply insight into how the world works, is ultimately based on the belief that this is a good thing to do. But it's something of a leap of faith to believe that that will leave the world a better place—the evidence to date is mixed for technical advances monotonically mapping onto human advances.

Naturally, this question has a technical spin for me. My current passion is the creation of tools for personal fabrication based on additive digital assembly, so that the uses of advanced technologies can be defined by their users. It's still no more than an assumption that that will lead to more good things than bad things being made, but, like the accumulated experience that democracy works better than monarchy, I have more faith in a future based on widespread access to the means for invention than one based on technocracy.

LAWRENCE KRAUSS

Physicist, Case Western Reserve University; Author, Atom

I believe our universe is not unique. As science has evolved, our place within the universe has continued to diminish in significance.

First it was felt that the Earth was the center of the universe, then that our Sun was the center, and so on. Ultimately we now realize that we are located at the edge of a random galaxy that is itself located nowhere special in a large, potentially infinite universe full of other galaxies. Moreover, we now know that even the stars and visible galaxies themselves are but an insignificant bit of visible pollution in a universe that is otherwise dominated by 'stuff' that doesn't shine.

Dark matter dominates the masses of galaxies and clusters by a factor of 10 compared to normal matter. And now we have discovered that even matter itself is almost insignificant. Instead empty space itself contains more than twice as much energy as that associated with all matter, including dark matter, in the universe. Further, as we ponder the origin of our universe, and the nature of the strange dark energy that dominates it, every plausible theory that I know of suggests that the Big Bang that created our visible

universe was not unique. There are likely to be a large, and possibly infinite number of other universes out there, some of which may be experiencing Big Bangs at the current moment, and some of which may have already collapsed inward into Big Crunches. From a philosophical perspective this may be satisfying to some, who find a universe with a definite beginning but no definite end dissatisfying. In this case, in the 'metaverse', or 'multiverse' things may seem much more uniform in time.

At every instant there may be many universes being born, and others dying. But philosophy aside, the existence of many different causally disconnected universes—regions with which we will never ever be able to have direct communication, and thus which will forever be out of reach of direct empirical verification—may have significant impacts on our understanding of our own universe. Their existence may help explain why our own universe has certain otherwise unexpected features, because in a metaverse with a possibly infinite number of different universes, which may themselves vary in their fundamental features, it could be that life like our own would evolve in only universes with a special set of characteristics.

Whether or not this anthropic type of argument is necessary to understand our universe—and I personally hope it isn't—I nevertheless find it satisfying to think that it is likely that not only are we not located in a particularly special place in our universe, but that our universe itself may be relatively insignificant on a larger cosmic scale. It represents perhaps the ultimate Copernican Revolution.

WILLIAM CALVIN

Neurobiologist, University of Washington; Author, *A Brief History of the Mind*

Dan Dennett has it right in his comments below when he puts the emphasis on acquiring language, not having language, as a precondition for our kind of consciousness. For what it's worth, I have some (likely unproveable) beliefs about why the preschooler's acquisition of a structured language is so important for all the rest of her higher intellectual function. Besides syntax, intellect includes structured stuff such as multistage contingent planning, chains of logic, games with arbitrary rules, and our passion for discovering "how things hang together."

Many animals have some version of a critical period for tuning up sensory perception. Humans also seem to have one for structured language, judging from the experience with the deaf children of hearing parents who are not exposed to a rich sign language during the preschool years. Oliver Sacks in "Seeing Voices" described an 11-year-old boy who had been thought to be retarded but proved to be merely deaf. After a year of ASL instruction, Sacks interviewed him:

> "Joseph saw, distinguished, categorized, used; he had no problems with perceptual categorization or generalization, but he could not, it seemed, go much beyond this, hold abstract ideas in mind, reflect, play, plan. He seemed completely literal—unable to juggle images or hypotheses or possibilities, unable to enter an imaginative or figurative realm.... He seemed, like an animal, or an infant, to be stuck in the present, to be confined to literal and immediate perception..."

In the first year, an infant is busy creating categories for the speech sounds she hears. By the second year, the toddler is busy picking up new words, each composed of a series of those phoneme building blocks. In the third year, she starts picking up on those typical combinations of words that we call grammar or syntax. She soon graduates to speaking long structured sentences. In the fourth year, she infers a patterning to the sentences and starts demanding proper endings for her bedtime stories. It is pyramiding, using the building blocks at the immediately subjacent level. Four levels in four years!

These years see a lot of softwiring via the pruning and enhancement of the prenatal connections between cortical neurons, partly on the basis of how useful a connection has been so far in life. Some such connections help you assemble a novel combination of words, check them for nonsense via some sort of quality control, and then—mirabile dictu—speak a sentence you've never uttered before. Some must be in workspaces that could plan not only sentences but an agenda for the weekend or a chain of logic or check out a chess move before you make it—even be tickled by structured music with its multiple interwoven melodies.

Then tuning up the workspace for structured language in the preschool years would likely carry over to those other structured aspects of intellect. That's why I like the emphasis on acquiring language as a precondition for consciousness: tuning up to sentence structure might make the child better able to perform at nonlanguage tasks which also need some structuring. Improve one, improve them all?

Is that what boosts our cleverness and intelligence? Is "our kind of consciousness" nothing but structured intellect with good quality control? Can't prove it, but it sure looks like a good candidate.

DANIEL C. DENNETT
Philosopher, Tufts University Author, Freedom Evolves

I believe, but cannot yet prove, that acquiring a human language (an oral or sign language) is a *necessary precondition* for consciousness–in the strong sense of there being a subject, an I, a 'something it is like something to be.' It would follow that non-human animals and pre-linguistic children, although they can be sensitive, alert, responsive to pain and suffering, and cognitively competent in many remarkable ways–including ways that exceed normal adult human competence–are not really conscious (in this strong sense): there is no organized *subject* (yet) to be the enjoyer or sufferer, no *owner* of the *experiences* as contrasted with a mere cerebral *locus* of *effects*.

This assertion is shocking to many people, who fear that it would demote animals and pre-linguistic children from moral protection, but this would not follow. Whose pain is the pain occurring in the newborn infant? There is not yet *anybody* whose pain it is, but that fact would not license us to inflict painful stimuli on babies or animals any more than we are licensed to abuse the living bodies of people in comas who are definitely not conscious. If selfhood develops gradually, then certain types of events only gradually become *experiences*, and there will be no sharp line between unconscious pains (if we may call them that) and conscious pains, and both will merit moral attention. (And, of course, the truth of the empirical hypothesis is in

any case strictly independent of its ethical implications, whatever they are. Those who shun the hypothesis on purely moral grounds are letting wishful thinking overrule a properly inquisitive scientific attitude. I am happy to give animals and small children "the benefit of the doubt" for moral purposes, but not for scientific purposes. Those who are shocked by my hypothesis should pause, if they can bear it, to notice that it is as just as difficult to prove its denial as its assertion. But it can, I think, be proven eventually. Here's what it will take, one way or the other:

> (1) a well-confirmed model of the functional architecture of adult human consciousness, showing how long-distance pathways of re-entrant or reverberant interactions have to be *laid down* and *sustained* by the sorts of self-stimulation cascades that entrain language use;
>
> (2) an interpretation of the dynamics of the model that explains why, absent these well-traveled pathways of neural micro habit, there is no functional unity to the nervous system–no unity to distinguish an *I* from a *we* (or a multitude) as the candidate subject(s) subserved by that nervous system;
>
> (3) a host of further experimental work demonstrating the importance of what Thomas Metzinger calls the phenomenal model of the intentionality relation (PMIR) in enabling the sorts of experiences we consider central to our own adult consciousness. This work will demonstrate that animal cleverness never requires the abilities thus identified in humans, and that animals are in fact incapable of appreciating many things we normally take for granted as aspects of our conscious experience.

This is an empirical hypothesis, and it could just as well be proven false. It could be proven false by showing that in fact the necessary pathways functionally uniting the relevant brain systems (in the ways I claim are required for consciousness) are already provided in normal infant or fetal development, and are in fact present in, say, all mammalian nervous systems of a certain maturity. I doubt that this is true because it seems clear to me that evolution has already demonstrated that remarkable varieties of adaptive coordination can be accomplished without such hyper-unifying meta-systems, by colonies of social insects, for instance. What is it like to be an ant colony? Nothing, I submit, and I think most would agree intuitively. What is it like to be a brace of oxen? Nothing (even if it is like something to be a single ox). But then we have to take seriously the extent to which animals–not just insect colonies and reptiles, but rabbits, whales, and, yes, bats and chimpanzees–can get by with somewhat *dis*unified brains.

Evolution will not have provided for the further abilities where they were not necessary for members of these species to accomplish the tasks their lives actually pose them. If animals were like the imaginary creatures in the fictions of Beatrix Potter or Walt Disney, they would have to be conscious pretty much the way we are. But animals are more different from us than we usually imagine, enticed as we are by these charming anthropomorphic fictions. *We* need these abilities to become persons, communicating individuals capable of asking and answering, requesting and forbidding and promising (and lying). But we don't need to be born with these abilities, since normal rearing will entrain the requisite neural dispositions. Human subjectivity, I am proposing, is thus a remarkable byproduct of human language, and no version of it

should be extrapolated to *any* other species by default, any more than we should assume that the rudimentary communication systems of other species have verbs and nouns, prepositions and tenses.

Finally, since there is often misunderstanding on this score, I am not saying that all human consciousness consists in *talking to oneself silently*, although a great deal of it does. I am saying that the ability to talk to yourself silently, as it develops, also brings along with it the abilities to review, to muse, to rehearse, recollect, and in general *engage* the contents of events in one's nervous system that would otherwise have their effects in a purely "ballistic" fashion, leaving no memories in their wake, and hence contributing to one's guidance in ways that are well described as unconscious. If a nervous system can come to sustain all these abilities without having language then I am wrong.

GEORGE B. DYSON
Science Historian; Author, Project Orion

Interspecies coevolution of languages on the Northwest Coast.

During the years I spent kayaking along the coast of British Columbia and Southeast Alaska, I observed that the local raven populations spoke in distinct dialects, corresponding surprisingly closely to the geographic divisions between the indigenous human language groups. Ravens from Kwakiutl, Tsimshian, Haida, or Tlingit territory sounded different, especially in their characteristic "tok" and "tlik."

I believe this correspondence between human language and raven language is more than coincidence, though this would be difficult to prove.

DANIEL GILBERT
Psychologist, Harvard University

In the not too distant future, we will be able to construct artificial systems that give every appearance of consciousness—systems that act like us in every way. These systems will talk, walk, wink, lie, and appear distressed by close elections. They will swear up and down that they are conscious and they will demand their civil rights. But we will have no way
to know whether their behavior is more than a clever trick—more than the pecking of a pigeon that has been trained to type "I am, I am!"

We take each other's consciousness on faith because we must, but after two thousand years of worrying about this issue, no one has ever devised a definitive test of its existence. Most cognitive scientists believe that consciousness is a phenomenon that emerges from the complex interaction of decidedly nonconscious parts (neurons), but even when we finally understand the nature of that complex interaction, we still won't be able to prove that it produces the phenomenon in question. And yet, I haven't the slightest doubt that everyone I know has an inner life, a subjective experience, a sense of self, that is very much like mine.

What do I believe is true but cannot prove? The answer is: You!

MARC D. HAUSER

Psychologist, Harvard University: Author, Wild Minds

What makes humans uniquely smart?

Here's my best guess: we alone evolved a simple computational trick with far reaching implications for every aspect of our life, from language and mathematics to art, music and morality. The trick: the capacity to take as input any set of discrete entities and recombine them into an infinite variety of meaningful expressions.

Thus, we take meaningless phonemes and combine them into words, words into phrases, and phrases into Shakespeare. We take meaningless strokes of paint and combine them into shapes, shapes into flowers, and flowers into Matisse's water lilies. And we take meaningless actions and combine them into action sequences, sequences into events, and events into homicide and heroic rescues.

I'll go one step further: I bet that when we discover life on other planets, that although the materials may be different for running the computation, that they will create open ended systems of expression by means of the same trick, thereby giving birth to the process of universal computation.

NICHOLAS HUMPHREY

Psychologist, London School of Economics; Author, The Mind Made Flesh

I believe that human consciousness is a conjuring trick, designed to fool us into thinking we are in the presence of an inexplicable mystery. Who is the conjuror and why is s/he doing it? The conjuror is natural selection, and the purpose has been to bolster human self-confidence and self-importance—so as to increase the value we each place on our own and others' lives.

If this is right, it provides a simple explanation for why we, as scientists or laymen, find the "hard problem" of consciousness just so hard. Nature has meant it to be hard. Indeed "mysterian" philosophers—from Colin McGinn to the Pope—who bow down before the apparent miracle and declare that it's impossible in principle to understand how consciousness could arise in a material brain, are responding exactly as Nature hoped they would, with shock and awe.

Can I prove it? It's difficult to prove any adaptationist account of why humans experience things the way they do. But here there is an added catch. The Catch-22 is that, just to the extent that Nature has succeeded in putting consciousness beyond the reach of rational explanation, she must have undermined the very possibility of *showing* that this is what she's done.

But nothing's perfect. There may be a loophole. While it may seem—and even be—impossible for us to explain how a brain process could have the quality of consciousness, it may not be at all impossible to explain how a brain process could (be designed to) *give rise to the impression* of having this quality. (Consider: we could never explain why 2 + 2 = 5, but we might relatively easily be able to explain why someone should be under the illusion that 2 + 2 = 5).

Do I want to prove it? That's a difficult one. If the belief that consciousness is a mystery is a source of human hope, there may be a real danger that exposing the trick could send us all to hell.

HOWARD GARDNER
Psychologist, Harvard University; Author, Changing Minds

The Brain Basis of Talent

I believe that human talents are based on distinct patterns of brain connectivity. These patterns can be observed as the individual encounters and ultimately masters an organized activity or domain in his/her culture.

Consider three competing accounts:

> #1 Talent is a question of practice. We could all become Mozarts or Einsteins if we persevered.
>
> #2 Talents are fungible. A person who is good in one thing could be good in everything.
>
> #3 The basis of talents is genetic. While true, this account misleadingly implies that a person with a "musical gene" will necessarily evince her musicianship, just as she evinces her eye color or, less happily, Huntington's disease.

My Account: The most apt analogy is language learning. Nearly all of us can easily master natural languages in the first years of life. We might say that nearly all of us are talented speakers. An analogous process occurs with respect to various talents, with two differences:

> 1. There is greater genetic variance in the potential to evince talent in areas like music, chess, golf, mathematics, leadership, written (as opposed to oral) language, etc.
>
> 2. Compared to language, the set of relevant activities is more variable within and across cultures. Consider the set of games. A person who masters chess easily in culture l, would not necessarily master poker or 'go' in culture 2.

As we attempt to master an activity, neural connections of varying degrees of utility or disutility form. Certain of us have nervous systems that are predisposed to develop quickly along the lines needed to master specific activities (chess) or classes of activities (mathematics) that happen to be available in one or more cultures. Accordingly, assuming such exposure, we will appear talented and become experts quickly. The rest of us can still achieve some expertise, but it will take longer, require more effective teaching, and draw on intellectual faculties and brain networks that the talented person does not have to use.

This hypothesis is currently being tested by Ellen Winner and Gottfried Schlaug. These investigators are imaging the brains of young students before they begin music lessons and for several years thereafter. They also are imaging control groups and administering control (non-music) tasks. After

several years of music lessons, judges will determine which students have musical "talent." The researchers will document the brains of musically talented children before training, and how these brains develop.

If Account #1 is true, hours of practice will explain all. If #2 is true, those best at music should excel at all activities. If #3 is true, individual brain differences should be observable from the start. If my account is true, the most talented students will be distinguished *not by differences observable prior to training* but rather by the ways in which their neural connections alter during the first years of training.

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