Copyright © 2022 By Edge Foundation, Inc. All Rights Reserved.

To arrive at the edge of the world's knowledge, seek out the most complex and sophisticated minds, put them in a room together, and have them ask each other the questions they are asking themselves.

https://www.edge.org/conversation/mirror-neurons-and-imitation-learning-as-the-driving-force-behind-the-great-leap-forward-in-human-evolution
Printed On Wed November 2nd 2022

CONVERSATION : MIND

Mirror Neurons and Imitation Learning as the Driving Force Behind the Great Leap Forward in Human Evolution

BY Vilayanur Ramachandran [5.31.00]

In 1995, to an audience of 6,000 scientists, V.S. Ramachandran (known to friends and colleagues as "Rama") delivered the inaugural "Decade of the Brain" lecture at the Silver Jubilee meeting of the Society for Neuroscience, this country's leading organization for brain research. His talk, laced with wit and humor, received a standing ovation. Ramachandran also delivered the "Decade of the Brain" lecture to the Library of Congress and the NIH. He received invitations to give the Dorcus Cumming Plenary Lecture at Cold Spring Harbor and the Weissman Memorial Lecture at the Weissman Institute, Israel. He is in great demand as a speaker, both for scientific and lay audiences.

Rama is on the editorial boards of several international journals and has published over 110 scientific papers, including three invited review articles for *Scientific American*. He edited a four-volume *Encyclopedia of Human Behavior* that was cited by *Library Journal* as "the most outstanding reference for 1994 in the behavioral sciences." In 1995, he was elected a member of the Atheneum, the world's oldest scientific club, founded in London by Michael Faraday and Humphrey Davy. He has appeared on numerous television programs (PBS, BBC, German television), and his work has been featured in *The New York Times*, *Discover*, *National Geographic*, *Time* and *Life*.

Originally trained as a physician at Stanley Medical College, where he was awarded gold medals in pathology and clinical medicine, Ramachandran went on to earn a PhD in neurology from Trinity College at Cambridge University. Before moving to La Jolla, he held appointments at Oxford University and the California Institute of Technology. In 1998, he received a gold medal from the Australian national university, and in '99 the Ariens Kappers Medal by the Royal Netherlands Academy of Sciences for landmark achievements in neurosciences. In the same year, he was elected a fellow of All Souls College Oxford. *Newsweek* named him a member of the "Century Club"—one of hundreds of people to watch as America enters the next century. Today he works exclusively with human neurological patients, and one of his main interests is in the neurological basis of art. He has been lecturing widely on this subject not only to scientists but also to art galleries and museums.

MIRROR NEURONS AND IMITATION LEARNING AS THE DRIVING FORCE

BEHIND "THE GREAT LEAP FORWARD" IN HUMAN EVOLUTION

[V.S. RAMACHANDRAN:] The discovery of mirror neurons in the frontal lobes of monkeys, and their potential relevance to human brain evolution—which I speculate on in this essay—is the single most important "unreported" (or at least, unpublicized) story of the decade. I predict that mirror neurons will do for psychology what DNA did for biology: they will provide a unifying framework and help explain a host of mental abilities that have hitherto remained mysterious and inaccessible to experiments.

There are many puzzling questions about the evolution of the human mind and brain:

1) The hominid brain reached almost its present size, and perhaps even its present intellectual capacity, about 250,000 years ago. Yet, many of the attributes we regard as uniquely human appeared only much later. Why? What was the brain doing during the long "incubation "period? Why did it have all this latent potential for tool use, fire, art, music and perhaps even language—that blossomed only considerably later? How did these latent abilities emerge, given that natural selection can only select expressed abilities, not latent ones? I shall call this "Wallace's problem," after the Victorian naturalist Alfred Russell Wallace, who first proposed it.

2) Crude "Oldawan" tools—made by just a few blows to a core stone to create an irregular edge—emerged 2.4 million ago and were probably made by *Homo habilis,* whose brain size was halfway (700cc) between modern humans (1300) and chimps (400). After another million years of evolutionary stasis, aesthetically pleasing "symmetrical" tools began to appear associated with a standardization of production technique and artifact form. These required switching from a hard hammer to a soft (wooden?) hammer while the tool was being made in order to ensure a smooth, rather than jagged, irregular edge. And lastly, the invention of stereotyped "assembly line" tools (sophisticated symmetrical bifacial tools) that were hafted to a handle, took place only 200,000 years ago. Why was the evolution of the human mind "punctuated" by these relatively sudden upheavals of technological change?

3) Why the sudden explosion (often called the "great leap") in technological sophistication, widespread cave art, clothes, stereotyped dwellings, etc., around 40,000 years ago, even though the brain had achieved its present "modern" size almost a million years earlier?

4) Did language appear completely out of the blue as suggested by Chomsky? Or did it evolve from a more primitive gestural language that was already in place?

5) Humans are often called the "Machiavellian Primate" referring to our ability to "read minds" in order to predict other people's behavior and outsmart them. Why are apes and humans so good at reading other individuals' intentions? Do higher primates have a specialized brain center or module for generating a "theory of other minds" as proposed by Nick Humphrey and Simon Baron-Cohen? If so, where is this circuit and how and when did it evolve?

The solution to many of these riddles comes from an unlikely source: the study of single neurons in the brains of monkeys. I suggest that the questions become less puzzling when you consider Giaccamo Rizzollati's recent discovery of "mirror neurons" in the ventral premotor area of monkeys. This cluster of neurons, I argue, holds the key to understanding many enigmatic aspects of human evolution. Rizzollati and Arbib have already pointed out the relevance of their discovery to language evolution. But I believe the significance of their findings for understanding other equally important aspects of human evolution has been largely overlooked. This, in my view, is the most important unreported "story" in the last

decade.

THE EMERGENCE OF LANGUAGE

Unlike many other human traits such as humor, art, dancing or music, the survival value of language is obvious—it helps us communicate our thoughts and intentions. But the question of how such an extraordinary ability might have actually evolved has puzzled biologists, psychologists and philosophers at least since the time of Charles Darwin. The problem is that the human vocal apparatus is vastly more sophisticated than that of any ape, but without the correspondingly sophisticated language areas in the brain, the vocal equipment alone would be useless. So how did these two mechanisms with so many sophisticated interlocking parts evolve in tandem? Following Darwin's lead, I suggest that our vocal equipment and our remarkable ability to modulate voice evolved mainly for producing emotional calls and musical sounds during courtship ("croonin a toon"). Once that evolved then the brain—especially the left hemisphere—could evolve language.

But a bigger puzzle remains. Is language mediated by a sophisticated and highly specialized "language organ" that is unique to humans and emerged completely out of the blue as suggested by Chomsky? Or was there a more primitive gestural communication system already in place that provided a scaffolding for the emergence of vocal language?

Rizzolatti's discovery can help us solve this age-old puzzle. He recorded from the ventral premotor area of the frontal lobes of monkeys and found that certain cells will fire when a monkey performs a single, highly specific action with its hand: pulling, pushing, tugging, grasping, picking up and putting a peanut in the mouth, etc., different neurons fire in response to different actions. One might be tempted to think that these are motor "command" neurons, making muscles do certain things; however, the astonishing truth is that any given mirror neuron will also fire when the monkey in question observes another monkey (or even the experimenter) performing the same action, e.g., tasting a peanut! With knowledge of these neurons, you have the basis for understanding a host of very enigmatic aspects of the human mind: "mind reading" empathy, imitation learning, and even the evolution of language. Anytime you watch someone else doing something (or even starting to do something), the corresponding mirror neuron might fire in your brain, thereby allowing you to "read" and understand another's intentions, and thus to develop a sophisticated "theory of other minds." (I suggest, also, that a loss of these mirror neurons may explain autism—a cruel disease that afflicts children. Without these neurons, the child can no longer understand or empathize with other people emotionally and therefore completely withdraws from the world socially.)

Mirror neurons can also enable you to imitate the movements of others, thereby setting the stage for the complex Lamarckian or cultural inheritance that characterizes our species and liberates us from the constraints of a purely gene-based evolution. Moreover, as Rizzolati has noted, these neurons may also enable you to mime—and possibly understand—the lip and tongue movements of others which, in turn, could provide the opportunity for language to evolve. (This is why, when you stick your tongue out at a new born baby it will reciprocate! How ironic and poignant that this little gesture encapsulates a half a million years of primate brain evolution.) Once you have these two abilities in place—the ability to read someone's intentions and the ability to mime their vocalizations—then you have set in motion the evolution of language. You need no longer speak of a unique language organ and the problem doesn't seem quite so mysterious any more.

(Another important piece of the puzzle is Rizzolatti's observation that the ventral premotor

area may be a homologue of the "Broca's area"—a brain center associated with the expressive and syntactic aspects of language in humans.)

These arguments do not in any way negate the idea that there are specialized brain areas for language in humans. We are dealing, here, with the question of how such areas may have evolved, not whether they exist or not.

Mirror neurons were discovered in monkeys, but how do we know they exist in the human brain? To find out, we studied patients with a strange disorder called anosognosia. Most patients with a right hemisphere stroke have complete paralysis of the left side of their body and will complain about it, as expected. But about 5% of them will vehemently deny their paralysis even though they are mentally otherwise lucid and intelligent. This is the so-called "denial" syndrome or anosognosia. To our amazement, we found that some of these patients not only denied their own paralysis, but also denied the paralysis of another patient whose inability to move his arm was clearly visible to them and to others. Denying one's paralysis is odd enough, but why would a patient deny another patient's paralysis? We suggest that this bizarre observation is best understood in terms of damage to Rizzolatti's mirror neurons. It's as if anytime you want to make a judgement about someone else's movements you have to run a VR (virtual reality) simulation of the corresponding movements in your own brain and without mirror neurons you cannot do this.

The second piece of evidence comes from studying brain waves (EEG) in humans. When people move their hands, a brain wave called the MU wave gets blocked and disappears completely. Eric Altschuller, Jamie Pineda, and I suggested at the Society for Neurosciences in 1998 that this suppression was caused by Rizzolati's mirror neuron system. Consistent with this theory, we found that such a suppression also occurs when a person watches someone else moving his hand, but not if he watches a similar movement by an inanimate object. (We predict that children with autism should show suppression if they move their own hands, but not if they watch someone else. Our lab now has preliminary hints from one highly functioning autistic child that this might be true (Social Neuroscience Abstracts 2000).

THE BIG BANG OF HUMAN EVOLUTION

The hominid brain grew at an accelerating pace until it reached its present size of 1500cc about 200,000 years ago. Yet, uniquely human abilities such the invention of highly sophisticated "standardized" multi-part tools, tailored clothes, art, religious belief and perhaps even language are thought to have emerged quite rapidly around 40,000 years ago—a sudden explosion of human mental abilities and culture that is sometimes called the "big bang." If the brain reached its full human potential—or at least size—200,000 years ago why did it remain idle for 150,000 years? Most scholars are convinced that the big bang occurred because of some unknown genetic change in brain structure. For instance, the archeologist Steve Mithen has just written a book in which he claims that before the big bang there were three different brain modules in the human brain that were specialized for "social or Machiavellian intelligence," for "mechanical intelligence" or tool use, and for "natural history" (a propensity to classify). These three modules remained isolated from each other, but around 50,000 years ago some genetic change in the brain suddenly allowed them to communicate with each other, resulting in the enormous flexibility and versatility of human consciousness.

I disagree with Mithen's ingenious suggestion and offer a very different solution to the problem. (This is not incompatible with Mithen's view, but it's a different idea). I suggest

that the so-called big bang occurred because certain critical environmental triggers acted on a brain that had already become big for some other reason and was therefore "pre-adapted" for those cultural innovations that make us uniquely human (one of the key pre-adaptations being mirror neurons). Inventions like tool use, art, math and even aspects of language may have been invented "accidentally" in one place and then spread very quickly given the human brain's amazing capacity for imitation learning and mind reading using mirror neurons. Perhaps ANY major "innovation" happens because of a fortuitous coincidence of environmental circumstances—usually at a single place and time. But given our species' remarkable propensity for miming, such an invention would tend to spread very quickly through the population—once it emerged.

Mirror neurons obviously cannot be the only answer to all these riddles of evolution. After all, rhesus monkeys and apes have them, yet they lack the cultural sophistication of humans (although it has recently been shown that chimps at least DO have the rudiments of culture, even in the wild). I would argue, though, that mirror neurons are necessary but not sufficient: their emergence and further development in hominids was a decisive step. The reason is that once you have a certain minimum amount of "imitation learning" and "culture" in place, this culture can, in turn, exert the selection pressure for developing those additional mental traits that make us human. And once this starts happening, you have set in motion the auto-catalytic process that culminated in modern human consciousness.

A second problem with my suggestion is that it doesn't explain why the many human innovations that constitute the big bang occurred during a relatively short period. If it's simply a matter of chance discoveries spreading rapidly, why would all of them have occurred at the same time? There are three answers to this objection. First, the evidence that it all took place at the same time is tenuous. The invention of music, shelters, hafted tools, tailored clothing, writing, speech, etc., may have been spread out between 100K and 5k and the so-called great leap may be a sampling artifact of archeological excavation. Second, any given innovation (e.g., speech or writing or tools) may have served as a catalyst for the others and may have therefore accelerated the pace of culture as a whole. And third, there may indeed have been a genetic change, but it may not have been an increase in the ability to innovate (nor a breakdown of barriers between modules as suggested by Mithen), but rather an increase in the sophistication of the mirror neuron system and therefore in "learnability." The resulting increase in ability to imitate and learn (and teach) would then explain the explosion of cultural change that we call the "great leap forward" or the "big bang" in human evolution. This argument implies that the whole "nature-nurture debate" is largely meaningless as far as humans are concerned. Without the genetically specified learnability that characterizes the human brain, *Homo sapiens* wouldn't deserve the title "sapiens" (wise), but without being immersed in a culture that can take advantage of this learnability, the title would be equally inappropriate. In this sense, human culture and human brains have co-evolved into obligatory mutual parasites—without either, the result would not be a human being (no more than you can have a cell without its parasitic mitochondria).

THE SECOND BIG BANG

My suggestion that these neurons provided the initial impetus for "runaway" brain/ culture co-evolution in humans isn't quite as bizarre as it sounds. Imagine a martian anthropologist was studying human evolution a million years from now. He would be puzzled (like Wallace was) by the relatively sudden emergence of certain mental traits like sophisticated tool use, use of fire, art and "culture," and would try to correlate them (as many anthropologists now do) with purported changes in brain size and anatomy caused by mutations. But unlike them,

he would also be puzzled by the enormous upheavals and changes that occurred after (say) the 19th century—what we call the scientific/industrial revolution. This revolution is, in many ways, much more dramatic (e.g., the sudden emergence of nuclear power, automobiles, air travel, and space travel) than the "great leap forward" that happened 40,000 years ago!

He might be tempted to argue that there must have been a genetic change and corresponding change in brain anatomy and behavior to account for this second leap forward (just as many anthropologists today seek a genetic explanation for the first one). Yet we know that present one occurred exclusively because of fortuitous environmental circumstances, because Galileo invented the "experimental method," that, together with royal patronage and the invention of the printing press, kicked off the scientific revolution. His experiments and the earlier invention of a sophisticated new language called mathematics in India in the first millennium AD (based on place value notation, zero and the decimal system) set the stage for Newtonian mechanics and calculus. "The rest is history," as we say.

Now the thing to bear in mind is that none of this need have happened. It certainly did not happen because of a genetic change in human brains during the renaissance. It happened at least partly because of imitation learning and rapid "cultural" transmission of knowledge. (Indeed, one could almost argue that there was a greater behavioral/cognitive difference between pre-18th century and post-20th century humans than between *Homo erectus* and archaic *Homo sapiens*. Unless he knew better, our Martian ethologist may conclude that there was a bigger genetic difference between the first two groups than the latter two species!)

Based on this analogy, I suggest further that even the first great leap forward was made possible largely by imitation and emulation. Wallace's question was perfectly sensible; it is very puzzling how a set of extraordinary abilities seemed to emerge "out of the blue." But his solution was wrong...the apparently sudden emergence of things like art or sophisticated tools was not because of God or "divine intervention." I would argue instead that just as a single invention (or two) by Galileo and Gutenberg quickly spread and transformed the surface of the globe (although there was no preceding genetic change), inventions like fire, tailored clothes, "symmetrical tools," and art, etc., may have fortuitously emerged in a single place and then spread very quickly. Such inventions may have been made by earlier hominids too (even chimps and orangs are remarkably inventive...who knows how inventive *Homo erectus* or Neandertals were), but early hominids simply may not have had an advanced enough mirror neuron system to allow a rapid transmission and dissemination of ideas. So the ideas quickly drop out of the "meme pool." This system of cells, once it became sophisticated enough to be harnessed for "training" in tool use and for reading other hominids minds, may have played the same pivotal role in the emergence of human consciousness (and replacement of Neandertals by *Homo sapiens*) as the asteroid impact did in the triumph of mammals over reptiles.

So it makes no more sense to ask "Why did sophisticated tool use and art emerge only 40,000 years ago even though the brain had all the required latent ability 100,000 years earlier?"—than to ask "Why did space travel occur only a few decades ago, even though our brains were preadapted for space travel at least as far back Cro Magnons?" The question ignores the important role of contingency or plain old luck in human evolutionary history.

Thus, I regard Rizzolati's discovery—and my purely speculative conjectures on their key role in our evolution—as the most important unreported story of the last decade.

Reality Club Discussion

Milford H. Wolpoff

Professor of Anthropology, University of Michigan; Adjunct Associate Research Scientist, Museum of Anthropology

MHW: I wouldn't know where to start with this, but please consider the following:

Marc Hauser's Point-1: 1) "The hominid brain reached almost its present size — and perhaps even its present intellectual capacity about 250,000 years ago . " What is the basis for this date? What is meant by ":intellectual capacity"? This sounds like the tired old argument from anthropology and other disciplines that the emergence of sophisticated tools, controlled fire, and so on represents the kind of fossilized evidence of intelligence that is most meaningful. I think a more carefully reasoned argument than this is necessary."

MHW: The evidence for this is quite good. Brain size has ben within the modern range, that is 2 sigma around the mean, for at least the last half million years, meaning that the differences are less than populational differences today, which cannot be meaningfully interpreted behaviorally. The widespread prepared core technique suggests complex rule systems by the 250,000 date, and the broad human adaptive pattern and markedly expanded range of archaeological sites, including glaciated areas, suggests the same. Burials are soon thereafter, and it is not a " tired old argument from anthropology" that supports this, but facts. What is tired and old is dismissing the abundant evidence for human prehistory and evolution for a snazzier theory based on "a more carefully reasoned argument". Fossils and archaeological remains are the direct evidence we have, and here we are luck because other species do not fossilize any remnants of their behavior.

Marc Hauser's Point-2: 3) "Why the sudden explosion (often called the "great leap") in technological sophistication, widespread cave art, clothes, stereotyped dwellings, etc. around 40 thousand years ago, even though the brain had achieved its present "modern" size almost a million years earlier?"

MHW: I'd suggest a title for this — the myths of human evolution — if it hadn't been used already. Parietal art in Europe is not this old, rock art is much older in Australia and Southern Africa. What about the "sudden explosion" of water craft in SE Asia 700,000 years ago when Flores was colonized, the sculpting in the Levant at 250,000, etc. This "explosion" is a Eurocentric interpretation of a much more complex and interesting history of human artistic and technological endeavors.

Why fall in to the pitfall of equating intellectual capacity, creativity and so on with brain size?"

MHW: Because we have very large brains and other primate species have much smaller ones? Because the brain is the seat of the intellectual capacity and creativity? Because no other credible explanation has been advanced for over 100 years?

I think much of the field has gone beyondthis, and certainly, Rama should be familiar with Deacon's excellent points on the difficulty of disentangling selection on brain size as opposed to body size. See the "Chihuahua fallacy".

MHW: Perhaps so, but the field has evidently not gone beyond missing the forest for the trees.

Hauser Point-3: 4)"Did language appear completely out of the blue as suggested by Chomsky? Or did it evolve from a more primitive gestural language that was already in place?"

MHW: yes

Hauser Point: "Why is the distinction between language arising out of nothing, and evolving from gestural systems? Why not explore the vocal communication of other animals, as many of us have done. "

MHW: is there yet a credible link between these and human language? Much evidence indicates that if human language has any links to primate communication systems, they are to gestural and ant vocal communications. But this, of course, comes from comparing living species to each other and not to ancestors.

Hauser Point: "Thus, given that no human culture has ever evolved a non vocal language as its primary means of communication, it seems odd to think that our language evolved from a gestural system. "

MHW: This makes no sense. "Evolved," of course, means changed, so how can an evolutionary argument be held to the criterion of not changing?--

Moreover, the best evidence to date on language-like forms of communication in animals come from their vocalizations, not their gestural systems. See my two books "The Evolution of Communication " and "Wild Minds".

MHW: Sure, but we did not evolve from "animals", but most directly from a common ancestor with chimpanzees, which gives us a clue about where to look.

Hauser Point-4: 5) Humans are often called the "Machiavellian Primate" referring to our ability to "read minds" in order to predict other peoples' behavior and outsmart them. Why are apes and humans so good at reading other individuals' intentions?

MHW: What? Apes reading others' intentions? Not so at all. In fact, there is almost no evidence that apes can read the intentions of others, except for a very recent paper by Hare, Tomasello and Call (2000, "Animal Behaviour"). All of the studies to date suggest that apes lack a theory of mind. See Tomasello and Call's Primate Cognitionand my Wild Minds.

Hauser Point-5: Do higher primates have a specialized brain center or module for generating a "theory of other minds" as proposed by Nick Humphrey and Simon Baron-Cohen?

MHW: Humphrey and Baron-Cohen are not responsible for the notion of theory of mind. This goes back to David Premack and Dan Dennett.

Hauser Point-6: "The problem is that the human vocal apparatus is vastly more sophisticated than that of any ape but without the correspondingly sophisticated language areas in the brain the vocal equipment alone would be useless. So how did these two mechanisms with so many sophisticated interlocking parts evolve in tandem? Following Darwin's lead I suggest that our vocal equipment and our remarkable ability to modulate voice evolved mainly for producing emotional calls and musical sounds during courtship ("croonin a toon."). Once that evolved then the brain — especially the left hemisphere — could evolve language."

MHW: and to think that when Frank Livingstone published a paper in 1962 entitled "could

australopithecines sing", it was met with peals of laughter.

Nicholas Humphrey
Emeritus Professor of Psychology, London School of Economics; Visiting Professor of Philosophy, New College of the Humanities; Senior Member, Darwin College, Cambridge; Author, Soul Dust

A FOOTNOTE TO THE HAUSER-RAMACHANDRAN EXCHANGE

I am not generally one to bother about reputation, but Marc Hauser's gratuitous put-down of my contribution to the theory of mind debate, prompts me to sound a note on my own behalf. Hauser "corrects" Ramachandran for suggesting that I was partly responsible for the idea that "higher primates have a specialized brain center or module for generating a 'theory of other minds'". Instead, he says, "this goes back to David Premack and Dan Dennett." However Ramachandran's scholarship on this score is actually rather better than Hauser's (as it might well be, since Ramachandran himself was in at the beginning).

There were of course important precursors, but the notion that the capacity to theorize about other minds is an evolved specialism, dependent on a new kind of cognitive architecture, was in fact first proposed by me in my Lister Lecture to the British Association for the Advancement of Science in 1977, and developed at a conference in 1978 organized by Ramachandran himself and Brian Josephson. The earliest published version appeared as "Nature's Psychologists," (New Scientist, 29 June 1978), and a longer version with the same title appeared in Josephson and Ramachandran's edited book, Consciousness and the Physical World (Pergamon, 1980).

Premack's famous paper "Do chimpanzees have a theory of mind" also appeared in 1978. It's true that in my own paper I did not use the phrase "theory of mind". Instead I wrote about how a "natural psychologist" has to develop a "conceptual model of how the mind works", based on an intuitive grasp of the "intervening variables and causal structure." However, the basic idea is just the same. What's more I went on to propose that in order to develop this kind of intuitive grasp, a newly evolved cognitive skill would be required. "The trick which nature came up with was introspection: it proved possible for an individual to develop a model of the behavior of others by reasoning by analogy from his own case, the facts of his own case being revealed to him by 'examination of the contents of consciousness'."

Dennett's ideas about higher order intentional systems were being developed, independently, around the same time.

Robert Provine
Professor Emeritus, University of Maryland, Baltimore County; Author, Curious Behavior: Yawning, Laughing, Hiccupping, and Beyond

Mirror Image Behavior: Yawning and Laughter

V. S. Ramachandran makes a strong case for the significance of mirror image neurons and associated imitative acts for understanding higher order behavior and its evolution. But the mechanism of imitation is a happy instance of a scientific problem that can be pursued by almost anyone — no electrophysiology laboratory is required. After spending many years seeking knowledge with a microelectrode, I became interested in simpler systems approaches to complex behavior using observations of normal human subjects. Yawning and laughter were selected for study because they offered the species-typicality and stereotypy important

to rigorous neurobehavioral analysis — and of central importance here — both are highly contagious. When we see someone yawn or hear someone laugh, we replicate the observed behavior, producing a chain-reaction of behavior that sweeps through a group. The contagious behavior is involuntary and compelling, involving the most direct communication possible — brain to brain — with our intellect just going along for the ride. We don't consciously decide to imitate the act we observed — it just happens. The virulence of contagious yawning and laughter is a fascinating display of Homo sapiens, the social animal. For neuroscientists, here we have the kind of behavior that is probably triggered by neurological feature detectors that are activated by observed yawns (in the visual domain) and laughter (in the auditory domain). When our yawn or laugh detectors are activated, they drive the neurological pattern generators that produce the acts of yawning or laughter. This a neural mechanism for a kind of "imitative" behavior.

One of the most attractive features of contagious yawning and laughter as a scientific problem is that we can use ourselves as subjects. For example, I have found that the yawning detector is broadly tuned — virtually any stimulus related to yawning will trigger it. Even reading about yawning will trigger yawns, a result that may be confirmed by many readers of this commentary. The contagiousness of laughter has even spawned its own technology, the notroious laugh tracks of television situation comedy.

Rafael Núñez
Professor, Department of Cognitive Science, University of California, San Diego

For a number of years I have admired Ramachandran's work. However, after reading his essay on mirror neurons I feel quite disappointed (... and, yes, I am aware that his piece was written for a chatty environment and not for an academic journal. My comments are also written in this spirit).

To avoid confusions, I must first say that I have no problems with Ramachandran's opening questions. Whether they are original or not, I find them interesting. I don't have problems either with his closing remarks ("So it makes no more sense to ask 'Why did sophisticated tool use and art emerge only 40,000 years ago even though the brain had all the required latent ability100,000 earlier?' ‹ than to ask 'Why did space travel occur only a few decades ago, even though our brains were pre- adapted for space travel at least as far back Cro Magnons?' "). In fact, George Lakoff and I have defended a similar position in our work on the embodied nature of mathematics, and the astonishing development of mathematics in the last century.

So, I have problems neither with Ramachandran's opening questions, nor with his closing remarks (other than the very last sentence: "I regard Rizzolati's discovery ... as the most important unreported story of the last decade"). But as it happens with sandwiches, what matters is often the stuff in the middle. That is where I have problems digesting Ramachandran's piece. Here is why.

1) His central prediction can be quite harmful.

Ramachandran opens with an enthusiastic prediction: "mirror neurons will do for psychology what DNA did for biology". I understand his enthusiasm, especially when seen from the perspective of his field, "visual psychophysics" (as he calls it), where the operationalization of relevant variables pushes to (sometimes extreme) reductionism.

But I think, as a scientist one should be more cautious. Ramachandran's prediction in fact has the potential to be quite harmful. It makes me think of those enthusiastic predictions made in the sixties by Herbert Simon, Marvin Minsky, and others, regarding the wonders of Artificial Intelligence, of General Problem Solving theory, and so on. The problem then was not that those influential predictions turned out to be false (in fact they never even came close to be true!). The problem was that in the meantime they did a lot of harm to the study of the richness, the subtleties, the dynamism, and the complexity of the human mind. In many ways we are still paying the price of thinking through the eyes of those predictions.

Although I don't think Ramachandran's prediction by itself can be that harmful, I think that reductionistic and simplistic predictions of this sort, when made by "prominent" people, can be quite dangerous. Paradoxically, I have to admit, in some (depressing) sense Ramachandran's prediction may be right. We may now, in psychology, spend futile time studying the sophistication of culture and mirror neurons in the way a number of biologists wasted their time looking for the genes responsible for being a criminal or a great basketball player.

2) His "necessary but not sufficient" condition is ambiguous.

Ramachandran's piece is articulated around the centrality (perhaps primacy?) of mirror neurons and imitation learning as "the driving force behind 'the great leap forward' in human evolution". His opening tone is quite radical. In fact, right after asking his introductory questions he says "The solution to many of these riddles comes from an unlikely source Š the study of single neurons in the brain of monkeys". Notice that he does not say "some preliminary suggestions come fromŠ", or "some pieces of the puzzle may be provided by Š", or anything like that. He categorically says "The Solution ... comes from". Later in the essay he washes out this dramatic statement by saying that "mirror neurons obviously cannot be the only answer to all these riddles of evolution" (good to hear that!), and that "mirror neurons are necessary but not sufficient".

My impression is that, in order to be consistent with his enthusiastic prediction, he would love to see mirror neurons as being the necessary and sufficient condition, or perhaps the main necessary condition required to address his questions (in particular if it is supposed to be "the most important unreported story of the last decade"), but he realizes that things are not that simple. The result is ambiguity.

3) Necessary but not sufficient, ... but how necessary?

When specifying that mirror neurons are necessary but not sufficient, Ramachandran mentions what for me is the real (and perhaps most) relevant issue: "After all rhesus monkeys and apes have them [mirror neurons], yet they lack the cultural sophistication of humans". From this, it seems clear to me that if we want to understand the "great leap", the emergence of language, and of cultural sophistication, etc., we can't start by saying that "the solution" to these questions comes from the study of single neurons in the brains of monkeys. To me, this is analogus to what I call the base-ten-arithmetic-because-of-ten-fingers argument: We developed our usual arithmetical base ten system, because we have ten fingers. Well, rhesus monkeys and apes also have ten fingers, and as far as we can tell they haven't developed anything even close to an arithmetic digital system.

In fact, over tens of thousands of years, there have been literally millions of fellow members of our species Homo sapiens who, although having ten fingers, never operated with base-ten arithmetic (or with any sophisticated arithmetic at all!). So where mirror neurons are

concerned, I would give no more relevance to them in explaining Ramachandran's questions over, say, the fully opposable thumb (and its neuromuscular complexity) of humans. Unlike mirror neurons, other primates don't have a fully opposable thumb. Moreover, there are a number of plausible accounts of how the uniqueness of the human thumb may have shaped the human brain, language, and culture. The scientific question then remains open: What allowed modern human primates, and not rhesus monkeys and apes, to achieve cultural sophistication? ... certainly not mirror neurons.

4) The survival value of language is not obvious.

As Jean-Louis Dessalles argues in his recent book Aux Origines du Langage, many scholars such as Steven Pinker, Philip Lieberman, Derek Bickerton, and others, assume that the survival value of language is "obvious". Ramachandran joins the list as he says "Unlike many other human traits such as humor, art, dancing or music the survival value of language is obvious it helps us communicate our thoughts and intentions". But, is it really obvious? It is certainly easier to say that something is obvious when we don't know how to actually explain it. If it is so obvious, why then is it that thousands of other species didn't develop language? Why didn't even the common chimp or the bonobos make it, even though they differ only in about 1.6% of their DNA from us?

From an anthropocentric view in which we see our species as the ultimate achievement of evolution, other species look somewhat "incomplete". Language then is seen as an essential feature of being complete, or at least more "advanced". When seen from this perspective the advantages of having language seem obvious. But telling the story from the perspective of what we know now, in which events are seen as inevitably leading to our present state, is completely misleading. By assuming that the survival value of language is obvious we hide the real scientific problem of the evolution of language (for an interesting discussion see Dessalles). In fact, today there is no scientific theory capable of satisfactorily explaining the mysterious problem of the evolution of language.

In short, the discovery of mirror neurons is certainly an extraordinary achievement, (as was the discovery of DNA). It may even be the case that it is indeed an important unreported scientific story, ... but I am afraid its importance is not supported by Ramachandran's speculations on their key role in human evolution.

William H. Calvin
Theoretical Neurobiologist; Affiliate Professor Emeritus, University of Washington; Author, Global Fever

For a half century, we have been aware of a big puzzle in human evolution. The Upper Paleolithic art and tools speak, as Richard Leakey said, "of a mental world we readily recognize as our own." It bursts on the scene rather suddenly about 40,000 years ago.

Ian Tattersall noted that this "stands in dramatic contrast to the relative monotony of human evolution throughout the five million years that preceded it. For prior to the Cro-Magnons, innovation was" sporadic at best." Adding to the puzzle is the fact that anatomically-modern Homo sapiens (big brain and all) was around for about 100,000 years before this efflorescence of cave art and fine toolmaking that signals the emergence of behaviorally-modern Homo sapiens.

Mirror neurons in the frontal lobe are the latest intriguing possibility for explaining the "Mindºs Big Bang." They are neurons, located in the monkeyºs version of Brocaºs area,

which might be involved in mirroring (that tendency of two people in conversation to mimic one another's postures and gestures. And, as such, candidates for what might be involved in the cultural spread of communicative gestures and perhaps even vocalizations.

First, imagine a neuron which buzzes away during certain actions and not others, say when the monkey picks up an object with its finger tips (but not when digging it out of a hole, when other neurons might buzz away instead). Some such neurons (the ones called mirror neurons) also buzz away when the monkey merely sees another monkey (or even human) do the same thing, often only out of the corner of its eye.

It isn't just the visual motion that stirs up these neurons; making the grasping gesture in mid-air won't work. It seems to require an object as well, much as most verbs require a noun for an associated theme to be expressed at the same time. And object movement alone won't stir the mirror neuron, as when the experimenter picks up the object with forceps instead of fingers. Sure sounds verb-like to me, and the mirror neurons are in roughly the part of the brain that, in humans, lights up during find-the-right-verb tasks.

The mirror neurons would seem to be just what you need for mirroring gestures, the confluence of the particular sensory representation and the particular movement-sequence production. And why has this stirred so many of us into enthusiastic extrapolations? Because humans are extraordinary mimics, compared to monkeys and apes, and mimicry surely helps in the cultural spread of language and toolmaking. So have we found the "seat of the meme"?

The Italian neurophysiologist who discovered the monkey mirror neurons, Giacoma Rizzolatti, does not claim so much. Indeed, he takes pains to bring flights of fancy back to the more limited hard data. At a recent conference on mirror neurons in Germany, every time someone mentioned mirror neurons as part of a neural circuitry for "see one, do one" mimicry, Rizzolatti would point out that they could equally be involved in simply understanding. Just as in language, where we know that there is a big difference between understanding a sentence and being able to construct and pronounce it, so mirror neurons might just be in the understanding business rather than the movement mimicry business. I take Rizzolatti's point (but temptation remains, so let me address mirroring's alternatives.

The British anthropologist Kenneth Oakley suggested in 1951 that the art-and-tools efflorescence might have been when fully modern language appeared on the scene. Was this because our ancestors got a lot more mirror neurons 40,000 years ago? Or did an already augmented human mirroring system merely help spread another biological or cultural invention in a profound way?

The latter would likely suffice because the profound improvement in language concerns structuring, not words or phrases per se. Mirroring had likely been aiding in the gradual development of novel vocalizations and words for a million years, and likely even short sentences (for which you don't need structural support). A great deal of what's important for language doesn't involve syntax, but structuring really makes long sentences fly, and likely complicated thoughts as well. Let me explain.

There are certainly major predecessors to structured language. Body postures communicate mood and intention (dogs communicate dozens), and arm or face posture sequences provide even more bandwidth for broadcasting your feelings and intentions. Species-specific vocalizations get a big addition from culturally-defined "words" (whether signed or spoken) whose learned meaning depends much more on context. Next comes word combinations,

such as short sentences. So far weºre mostly talking about what Derek Bickerton in 1990 called "protolanguage," and this unstructured language (you can guess the meaning without any help from word order or inflections) is what you see in toddlers and speakers of pidgins.

Long sentences, however, are too ambiguous without some mutually understood conventions about internal structuring into phrases and clauses. A clause may be embedded in a phrase, and vice versa, ad infinitum. Such conventions constitute syntax and each dialect has a different way of doing things. "Universal grammar" is simply the tendency of all human groups to use a restricted set of structuring possibilities; not every scheme is possible, and that likely has something to do with the way in which the human brain is wired.

Once you have a syntax (kids pick them up between 18 and 36 months), you can convey complicated thoughts. And hopefully think them first, so as to avoid that blues lament of Mose Allison, about when "Your mind is on vacation but your mouth is working overtime."

It is this last step up to syntax that is the usual candidate for the mindºs big bang, not the language-lower-case stuff that, though essential, falls short of structuring per se. And not augmented cultural spread, as mirror neurons might help with. But I think that it isnºt syntax per se. Rather, it may be all the higher intellectual functions that emerged so dramatically 50,000 years ago (that the same neural machinery is likely used by syntax, planning, multipart music, chains of logic, and our fascination with discovering hidden patterns in our sensory environment. Improve one, improve all of structured thought.

But while Iºd guess that augmented structuring of thought was likely responsible for the suddenness of the 40,000-years-ago transition, youºve still got to spread it around. Was it a matter of spreading genes or memes? You canºt rule out genes at this point, given that newly-discovered Y chromosome bottleneck at about the same time, but culture might well have sufficed. Mirroring novel sequences, as in learning how to dance, may have been the key to spreading structured thought around the world so quickly as a cultural conquest.

I would like to respond to a few of the issues raised by Rama's essay on mirror neurons. I don't disagree at all about the importance of mirror neurons, but I do disagree with some of the points that Rama makes about evolution, primates, language, and the interface between brain and behavior. I pick on these points as they appear.

Point-1: "1) The hominid brain reached almost its present size — and perhaps even its present intellectual capacity about 250,000 years ago."

MDH: What is the basis for this date? What is meant by ":intellectual capacity"? This sounds like the tired old argument from anthropology and other disciplines that the emergence of sophisticated tools, controlled
fire, and so on represents the kind of fossilized evidence of intelligence
that is most meaningful. I think a more carefully reasoned argument than
this is necessary.

Point-2: "3) Why the sudden explosion (often called the "great leap") in technological sophistication, widespread cave art, clothes, stereotyped dwellings, etc. around 40 thousand years ago, even though the brain had achieved its present "modern" size almost a million years earlier?"

MDH: Why fall in to the pitfall of equating intellectual capacity, creativity and so on with

brain size? I think much of the field has gone beyond this, and certainly, Rama should be familiar with Deacon's excellent points on the difficulty of disentangling selection on brain size as opposed to body size. See the "Chihuahua fallacy."

Point-3: "4) Did language appear completely out of the blue as suggested by Chomsky? Or did it evolve from a more primitive gestural language that was already in place?"

MDH: Why is the distinction between language arising out of nothing, and evolving from gestural systems? Why not explore the vocal communication of other animals, as many of us have done. Thus, given that no human culture has ever evolved a non-vocal language as its primary means of communication, it seems odd to think that our language evolved from a gestural system. Moreover, the best evidence to date on language-like forms of communication in animals come from their vocalizations, not their gestural systems. See my two books The Evolution of Communication and Wild Minds.

Point-4: "5) Humans are often called the "Machiavellian Primate" referring to our ability to "read minds" in order to predict other peoples' behavior and outsmart them. Why are apes and humans so good at reading other individuals' intentions?"

MDH: What? Apes reading others' intentions? Not so at all. In fact, there is almost no evidence that apes can read the intentions of others, except for a very recent paper by Hare, Tomasello and Call (2000, "Animal Behaviour"). All of the studies to date suggest that apes lack a theory of mind. See Tomasello and Call's Primate Cognitionand my Wild Minds.

Point-5: "Do higher primates have a specialized brain center or module for generating a 'theory of other minds' as proposed by Nick Humphrey and Simon Baron-Cohen?"

MDH: Humphrey and Baron-Cohen are not responsible for the notion of theory of mind. This goes back to David Premack and Dan Dennett.

Point-6: "The problem is that the human vocal apparatus is vastly more sophisticated than that of any ape but without the correspondingly sophisticated language areas in the brain the vocal equipment alone would be useless. So how did these two mechanisms with so many sophisticated interlocking parts evolve in tandem? Following Darwin's lead I suggest that our vocal equipment and our remarkable ability to modulate voice evolved mainly for producing emotional calls and musical sounds during courtship ("croonin a toon"). Once that evolved then the brain — especially the left hemisphere — could evolve language."

MDH: Several problems here. First, the importance of the vocal apparatus and underlying neural structure is not a new one, and is best attributed to Phil Lieberman. Second, because language is not really about the sound structure per se — sign language is an equally good natural language unless communication in dense vegetation is of the essence — a focus on sound and vocal mechanisms per se is probably misguided. Third, although the human vocal tract is different from the vocal tract of other animals, more "sophisticated" is the wrong classificatory system. The vocal maneuvers of a bird or a bat are extremely complicated, and we can't come close to imitating their sounds. Moreover, many of the early claims concerning the lack of articulatory abilities in primates are simply wrong, even though nonhuman primates can't produce many of the sounds of human speech. Finally, the argument that language somehow emerged from emotional calls seems really quite impossible since the structure and function of these calls have so few of the crucial properties of natural language: no reference, no syntax, no decomposable discrete elements that can be recombined.

Point-6: "Mirror neurons can also enable you to imitate the movements of others thereby setting the stage for the complex Lamarckian or cultural inheritance that characterizes our species and liberates us from the constraints of a purely gene based evolution. Moreover, as Rizzolati has noted, these neurons may also enable you to mime — and possibly understand — the lip and tongue movements of others which, in turn, could provide the opportunity for language to evolve. (This is why, when you stick your tongue out at a new born baby it will reciprocate! How ironic and poignant that this little gesture encapsulates a half a million years of primate brain evolution.) Once you have these two abilities in place the ability to read someone's intentions and the ability to mime their vocalizations then you have set in motion the evolution of language. You need no longer speak of a unique language organ and the problem doesn't seem quite so mysterious any more."

MDH: This is all fine and good, but there is a puzzle that Rama fails to address: Although mirror neurons were first discovered in macaques, and have been implicated as crucial in imitation and theory of mind, there is not a shred of evidence for imitation or theory of mind in macaques. Thus, from a functional perspective, what is this circuitry doing for a macaque? It is certainly not what Rama has suggested for humans.

Point-7: "These arguments do not in any way negate the idea that there are specialized brain areas for language in humans. We are dealing, here, with the question of how such areas may have evolved, not whether they exist or not."

MDH: Because of the comment in point 6, the evolutionary problem is even more challenging. How do you go from a set of circuits in macaques that may guide motor actions, and perceptions of them, to implementing such circuits in the service of much more complicated cognitive acrobatics: imitation and mind reading? Moreover, if you are going to make the evolutionary point, it is important to articulate the selective forces that may have led to such cognitive changes.

Point-8: "I suggest that the so-called big bang occurred because certain critical environmental triggers acted on a brain that had already become big for some otherreason and was therefore "pre-adapted" for those cultural innovations that make us uniquely human. (One of the key pre adaptations being mirror neurons.) Inventions like tool use, art, math and even aspects of language may have been invented "accidentally" in one place and then spread very quickly given the human brain's amazing capacity for imitation learning and mind reading using mirror neurons. Perhaps ANY major "innovation" happens because of a fortuitous coincidence of environmental circumstances — usually at a single place and time. But given our species' remarkable propensity for miming, such an invention would tend to spread very quickly through the population — once it emerged."

MDH: This idea is unfortunately not new at all. Many people have argued for the importance of imitation in human evolution, arguing that it has had cataclysmic effects in all sorts of domains. Both Merlin Donald and Michael Tomasello make this point quite eloquently, although they do not make any appeals to mirror neurons.

Point-9: "Thus I regard Rizzolati's discovery — and my purely speculative conjectures on their key role in our evolution — as the most important unreported story of the last decade."

MDH: I have no problem with the point that mirror neurons represent a key finding. As noted above, I do have several problems with Rama's claims, both in terms of their factual correctness, and their originality.

Thanks to both Rama and Nick for their replies. In order to quell any further claims of X not understanding Y, let me simply make a few points. I was not making a blanket claim that Edge should be a forum for only original points. Not at all. This would completely defeat the purpose of such a digital salon. I was making specific comments about specific points. I was also not saying that Rama hasn't made many important original comments, and findings. His own work is some of the most profound around and I cite it all the time (note: I don't care about the lack of citation to my own work; that wasn't the point!).

Second, I wasn't saying that fire, tools, etc. are not important in thinking about the evolution of human culture, nor that these are not indices of human intellectual capacity. Rather, what I was pointing to is the fact that is commonly assumed that because these are such extraordinary achievements, that they must be evidence that such humans had language. But the connection between language and such abilities is never explicitly articulated. I don't have an argument to make here, but I am very much against claims that simply invoke language without saying, first, what it is about language that makes such cognitive abilities possible, and second, articulating how it happened.

Third, Rama suggests I read Povinelli. Uggh. Rama should read Povinelli and see all the critiques that have emerged. For example, in Povinelli's original experiment using the knower-guesser procedure, he claimed that chimps, but not rhesus have a theory of mind because they can recognize ignorance. However, a careful analysis of his data (i..e, as opposed to his interpretation) revealed (see C. Heyes, 1998, BBS for one critique; there were many others) that not only did the chimps take hundreds of trials to discriminate between knower and guesser (i.e., no theory of mind at all), but in the key transfer test, the chimps failed as well. So, nothing at all in Povinelli provides evidence of theory of mind, and in fact, if Rama had read recent Povinelli, he too would see that Povinelli himself claims that chimps lack this ability; so does Mike Tomasello, another exceptional researcher in this field.

While on the topic, I also did not mean to slight Nick Humphreys. I have long been an admirer! Given lectures and research that is not published, I think what I was trying to point out is that David Premack's chimp experiments were conducted well before the BBS publication and Premack made a big deal of this as a specialized mechanism. Of course Premack argued that the chimps did have a theory of mind, but in this particular experiment at least, the same problems arise as those in Povinelli. The chimps don't spontaneously assign the correct mental states to humans as actors.

Finally, I didn't miss the point at all about emotional calls and language. I got it. And I don't agree with it. The way in which we modulate our voice for emotional calls is not sophisticated at all. It doesn't require the rapid bit rate that is critical in speech, a point made by Lieberman many years ago. In any case, I have very much enjoyed this. This is, after all, what a salon is all about!

Vilayanur Ramachandran
Neuroscientist; Professor & Director, Center for Brain and Cognition, UC, San Diego; Author, The Tell-Tale Brain

RESPONSE TO MARC HAUSER'S COMMENTS

Milford Wolpoff has done an adequate job in refuting the various purported " criticisms" of my essay raised by Marc Hauser . But here are my own reactions to Hauser. For what it is worth.

First, Hauser seems not to understand the purpose of the Edge website. He says the ideas in the essay (or at least some of them) are not " original" but I wasn't even tryingto be original. The purpose of this website is to provide a platform for exchange of ideas and my goal was to be provocative — not original. Judging from the arguments I have already generated between Wolpoff and Hauser, I appear to have succeeded in doing this. (Needless to say I agree with Wolpoff!) Secondly, John Brockman's invitation to me was to report on "The most important unreported story" — not on mystory, but on any story The choice of someone else's work — Rizzolati's — was quite deliberate, because its significance is not widely appreciated, except by experts in the field. (And not even by all "experts.")

But having said that let me add that, despite Hauser's comment, there are many points in my essay that are original, e.g. our work on anosognosia patients denying the paralysis of other patients or on MU wave suppression that occurs while you watchanother persons movements. Also the point I make about the analogy between the "second big bang" in human culture (following the industrial/scientific revolution) and the so-called "big bang" of 40,000 years ago has, to my knowledge, not been made before. The argument is: we know that there could have been no genetic change in the brain corresponding to the second big bang, so why do so many paleoanthropologists feel the compelling need to invoke one for the first?

I turn now to some of the other issues. Hauser's remarks suggest that he hasn't read my article carefully. (Since he appears not to understand the ideas or, in some cases, simply repeats what I say but pretends to disagree.)

1) Brain size. I certainly don't think there is a direct and simple correlation between brain size and intelligence. I was setting up this argument merely as a "straw man," as a rhetorical device, and if Hauser had read on further he would have realized this. Indeed my essay concludes by saying that it isn't size but circuitry that is critical, specifically the circuitry in the ventral premotor area where the mirror neurons are. Thus Hauser is actually agreeing with me although he pretends not to.

Secondly Hauser says (under his point no. 1) "What is meant by intellectual capacity ? This sounds like the tired old argument from anthropology and other disciplines that the emergence of sophisticated tools, controlled fire, and so on represents a kind of fossilized evidence of intelligence" If sophisticated tools, fire, shelters, woven clothing etc are not evidence of intelligence, then what IS? Perhaps Hauser would prefer that we went back in a time machine to visit early hominids to administer " I Q tests" of the kind popularized by his former colleague — the late Dick Herrenstein? Here I am in complete agreement with Wolpoff that cognitive psychologists should start paying attention to the evidence from paleoanthropology.

2) Hauser asks: Monkeys have mirror neurons so why don't they have an elaborate culture like us? Again if he had bothered to read the essay he will seen that I raise the very same question twice in my article. Hauser's confusion stems from a failure to distinguish necessary and sufficient conditions. I argue in my essay that the mirror neuron system — and its subsequent elaboration in hominids- may have beennecessary but not sufficient . But it may have been a decisive step. Hauser appears not to understand this idea. .

3) Theory of other minds.. Hauser categorically states that apes " do not have a theory of other minds". He should read the elegant work of Povinelli. I would agree with Hauser, though, that it would be nice to see clearer proof of the kind I am accustomed to in my own

field (visual psychophysics) But as I said above (2) even if apes did not have a theory of other minds, this wouldn't vitiate my main argument. Perhaps mirror neurons are necessary, but they may not be sufficient for generating a theory of other minds.

4) Priority: Hauser says that the idea of a specialized mechanism in humans (and perhaps apes) for reading other minds came from David Premack and Dan Dennett notfrom Nick Humphrey or Simon Baron — Cohen. Hauser may be right about this- I am not sure. Dennett is a sophisticated and original thinker and he may very well have thought of it .The earliest Humphrey reference I can think of is 1977 at a symposium I organized in Cambridge, UK (published) Can Hauser provide an earlier Dennett reference? And I am aware of Premark's ingenious experiments but did he explicitly state that there may be a specialized mechanism for reading other minds? In any event my essay was an entry for a website chat room — not for a stuffy journal like psych review. (If it had been the latter I would have been more diligent with citations and issues of priority) There aredozens of others whom I could have cited. (Including Hauser's own interesting work : perhaps he is peeved that I didn't cite him) but that would have been beyond the scope of such a short essay.

5) Hauser argues that my my remarks about the important role of culture in evolution are " not new". Again I wasn't pretending it was new .. of course it isnt new, its been made a thousand times.(most recently and eloquently by Merlin Donald) What's new is the link with a specific mechanism — mirror neurons (Or at least, this point isn't widely appreciated.. and in that sense it satisfies the requirements of John Brockman's original question " what's the single most unreported story") 6) Hauser says " The evolutionary problem is even more challenging. How do you go from a set of circuits in macaques that may guide motor actions, and perceptions of them, to implementing such circuits in the service of much more complicated cognitive acrobatics: imitation and mind reading?" Here,at last, is a good point from Hauser and I would agree with him.. indeed its a point that everyone, including Rizzolati — is perfectly aware of. But I would argue that mirror neurons provide an experimental lever for addressing these issues empirically instead of just speculating about how it might have happened.

7) Hauser argues "Finally, (Ramachandran's) argument that language somehow emerged from emotional calls seems really quite impossible since the structure and function of these calls have so few of the crucial properties of natural language: no reference, no syntax, no decomposable discrete elements that can be recombined." Here again Hauser has missed my point. I argued that it was initially the need for modulating the voice for emotional calls (and perhaps singing) that exerted the selection pressure for the development of sophisticated vocal apparatus (and neural networks). But once these mechanisms for subtle voice modulations were in place they provided a preadaptation — an opportunity — for language to evolve. Contrary to Hauser's remark I certainly wasn't saying that "language evolved from emotional calls." That would be ludicrous.

8) Hauser says "The vocal maneuvers of a bird or a bat are extremely complicated, and we can't come close to imitating their sounds". Again Hauser confuses necessary and sufficient conditions. The emergence of vocal sophistication may have been necessary for language evolution (as I point out) but certainly not sufficient (parrots don't have language!)

In summary, I suggest Hauser read my essay again and also read Wolpoff's refutation of the many points he raises. But I thank him for his response, for it raises many interesting and fascinating issues that need to be widely discussed.

Or perhaps we would all be better off following the advice given by the French Anthropological Society in the 19th century and banning all ideas about the evolution of language! (That's why I tried to emphasize culture in my essay rather than language per se.)

It seems to me that Mark and I are now starting to see eye to eye on most of these issues (although I cant speak for Wolpoff and Humphrey).

Having looked at Povinelli again, I agree that the evidence for apes having a theory of other minds is ambiguous, at best. (I suspect that part of the problem is that one has to distinguish between an explicit theory of other mind and an "implicit" one.) But as I said in my response even if they don't, it doesn't vitiate my main argument that mirror neurons may have provided the "scaffolding" for the subsequent emergence of this ability ‹ I.e. the mirror neuron system may have been necessary for its emergence but not sufficient. It's a bit like legs being precursors of whale flippers...to use a crude analogy. Or the evolution of multiple specialized visual areas ‹ through gene duplication ‹ from an earlier primordial less specialized visual area (as noted by John Allman for visual areas).

I also agree with Mark that sophisticated tools, transport, shelter and clothing are not necessarily evidence of language (I never said they were) but I'd argue they are certainly signs of intelligence (if that word has any meaning at all). So on this point we probably agree ‹ at least we do now. Indeed the mirror neuron system would allow communication of complex skills without the intervention of language! Contrary to the views of some scholars, you don't need language to teach skills.

On the issue of originality we need to credit Mark for being one of the first to point out the inadequacy of the evidence that Apes have a theory of other minds. And as for human brains and culture being mutually obligatory parasites (my terminology) there are lots of people we need to credit...including (most recently) Dawkins and Sue Blackmore. But, again, they don't discuss mirror neurons, and in my view the discovery of this system gives the whole topic more credibility than in the past, in addition to providing an experimental lever for approaching it empirically rather than theoretically.

VSR

p.s. Everyone has his or her favorite chimp story...here's mine.

Chimps in Madras zoo live in a very large island surrounded by a moat. I was chatting with the keeper on one side of the moat when a chimp ran towards the edge of the island where we were making frantic sounds and gestures. He (or she) then seemed to beckon us to follow him around as he ran towards the other side of the island.

Having got there he reached for a large red stone and, to our amazement, threw it at a vendor standing and grinning on the other side! The chimp seemed very agitated, jumping up and down screaming. Seeing our amazed expression one of the people in the vicinity came and told us what had happened: The vendor had apparently hurled the red stone at the chimp a few minutes earlier to tease him. Infuriated, the chimp had come to "complain" to the Keeper and had done so by beckoning him to his region of the island and throwing the red stone back at the vendor, either as "revenge" or to "tell" the keeper what had happened. Perhaps this episode had made me read more into Povinelli's earlier experiments than I

should have! (And perhaps there is a simple, less "anthropomorphic" explanation of the Chimp's behavior). But my personal feeling is that the question of Apes modelling other minds is still open despite Povinelli's retreat.

What's Related

People

Vilayanur Ramachandran
Neuroscientist; Professor & Director, Center for Brain...

Contributors

Rafael Núñez
Professor, Department of Cognitive Science,... **[Read]**

Robert Provine
Professor Emeritus, University of Maryland,... **[Read]**

Nicholas Humphrey
Emeritus Professor of Psychology, London School... **[Read]**

Milford H. Wolpoff
Professor of Anthropology, University of Michigan... **[Read]**

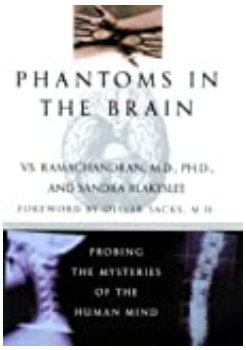
Vilayanur Ramachandran
Neuroscientist; Professor & Director, Center... **[Read]**

William H. Calvin
Theoretical Neurobiologist; Affiliate Professor... **[Read]**

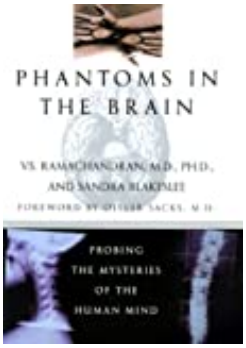
Beyond Edge

Vilaynur Ramachandran Home Page

Books



Phantoms in the Brain: Probing the Mysteries...
By **Vilayanur Ramachandran** Hardcover



Phantoms in the Brain: Probing the Mysteries...
By **Vilayanur Ramachandran** Hardcover

Events

THE EDGE "BILLIONAIRES' DINNER" 2007
Edge Dinners [3.6.07]

Tags

mirror neurons
neuroscience

Conversations at Edge

Adventures in Behavioral Neurology—Or—What Neurology Can Tell Us About Human Nature
[2.21.12]

Self-Awareness: The Last Frontier
[1.1.09]

The Neurology of Self-Awareness
[1.8.07]

Mirror Neurons and the Brain in the Vat
Introduction by
John Brockman
[1.9.06]

The Astonishing Francis Crick
[10.17.04]

Contact Info:editor@edge.org

Edge.org is a nonprofit private operating foundation under Section 501(c)(3) of the Internal Revenue Code.
Copyright © 2022 By Edge Foundation, Inc All Rights Reserved.