Q & A

V.S. Ramachandran

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What made you choose Biology? Let me answer by disagreeing with one of the scientists you have already interviewed, Steve Pinker (whom I admire, by the way). He says that we should not trust scientists' recollections about their careers because memories are highly unreliable. Using a Pinker-style evolutionary logic I would argue the very opposite: memories are highly *reliable*, otherwise we would not have survived! The fact that it is occasionally fallible does not mean that memory should not be trusted, any more than I should not trust my senses just because I occasionally hallucinate or enjoy visual illusions!

I remember well why I got into biology. I found physics *too* exact, and sterile for my taste, and psychology too woolly. Biology was the right combination of precision and complexity. When I later got into human vision and neurology, I found that they were areas in which one could still do 'Victorian' style experiments that *could* have been done 100 years ago, but weren't. You see I have this perverse streak; I enjoy doing things which make my competitors say "That is so simple; why didn't I think of it?", or "It is too simple — it cannot be right".

A third, more mundane reason is that I always enjoyed collecting fossils and sea shells, and through taxonomy and comparative anatomy I became hooked on evolution. Surprisingly, evolutionary thinking is rare in neurology, but it permeates every aspect of my work, including my early work on color and motion, and the visual perception of object shape from shading information, and my recent speculations on synesthesia, the evolution of metaphor and autism. For example, in 2000, I suggested that the synesthesia gene(s) survived because it makes some outliers in the population more 'metaphorical' and creative; there is a hidden agenda, as with the sickle-cell anemia gene.

Were you a good student? Yes and no; I was erratic. My performance in science was perfectly respectable, but in languages, and humanities in general, it was abysmal. But I also surprised all my classmates when a paper I sent to *Nature* when I was just 20 was accepted and published without revision!

Which paper had the most influence on you? My early interest in Vision was sparked by Richard Gregory's 1958 paper on why the world remains stable during eye movements (Eye movements and the stability of the visual world. Nature *182*, 1214-1216) and his subsequent squabbles with Donald McKay. (I think they were both right, by the way.) And Bela Julesz's papers taught me that one could draw important conclusions from amazingly simple experiments.

Any scientific heroes? Michael Faraday and Thomas Huxley. Faraday moved a magnet within a coil of wire and linked two entire fields of physics: electricity and magnetism. From this I learnt that there is no correlation between the sophistication of methodology and technology and the importance of the result. And Huxley for his overall approach, for his wit and pugnacity and for bringing science to 'the common people' — his phrase — without dumbing it down.

Also the unknown Indian genius in the first millennium BC who combined the use of *place* value in number representations, base 10 (far more practical than the Sumerian 60) and, most importantly, zero as an independent number and place holder. This marks the dawn of mathematics.

What about modern-day heroes? Richard Gregory, Norm Geschwind and Francis Crick, all of whom have had more sheer fun doing science than anyone else I know.

Do you think the peer review system works? I can do no better than quote Semir Zeki: "referees are swine but sometimes swine can lead you to the truffle".

What is the best advice you have ever been given? All from Francis Crick, as I pointed out in a recent memorial at the Salk Institute (The astonishing Francis Crick. Perception *33*, 1151–1154).

First, the importance of sheer intellectual daring — chutzpah. It is better to tackle ten fundamental problems and solve one than to tackle ten trivial ones and solve them all! Fundamental problems are not necessarily more inherently difficult than trivial ones. Nature is not conspiring against us to make fundamental problems more difficult.

Second don't become trapped in a small, specialised cul-de-sac just because you feel comfortable or your immediate peers reward you for it. Don't strive for approval from the majority of your colleagues, but only for the respect of those few exceptional people at the top of your field whom you genuinely admire. And

never listen to 'experts' — recall how both Erwin Chargaff and William Bragg strongly discouraged Crick from pursuing DNA!

Do you have a favorite conference? I don't like any of them. I bet I could write a computer program that randomly strings together the key words from this year's abstracts at the big neuroscience meetings and produces perfectly acceptable abstracts for next year. Of course you don't want to be an ostrich, but the danger for young people is that they might get drawn into fashionable trends instead of tackling fundamental questions starting from first principles.

Why the interesting in popularizing science? I do it for three reasons. First, because it is fun. Second, we owe it to the tax-paying public whose patronage we enjoy. And third, as a reaction to the phase we went through when it was not considered the 'proper' thing for a researcher to do. There are many outstanding scientists who now "popularize" science in their spare time: Lewis Wolpert, John Barrow, Steve Pinker, Stephen Hawking, Roger Penrose, Edward Wilson, and Mike Gazzaniga, to name just a few.

So overall it is a good thing to do, although inevitably there will be a few envious colleagues who secretly wish to do the same but lack the talent. A greater danger is that one might inadvertently oversimplify some of the concepts and offend some experts. But as Lord Reith said, "There are some people whom it is one's duty to offend".

What are the key problems in your field that interest you? One is the neural basis of abstract thinking — how do we use neurons to juggle ideas sequentially in our heads? As when you say: A is bigger than B, B is bigger than C, therefore A must be bigger than C. Is our ability to make such a *deduction* about the transitivity of relations learned through *induction*, from the way that, every time you saw that A>B and B>C, then it always turned out empirically that A>C? And if so, is this ability to induce rules acquired through learning or hardwired through natural selection? Did transitivity evolve mainly to make beneficial social inferences — that chap A just beat up B, and B beat me up, so clearly A is stronger than me and I had better watch out for him — *before* it was adopted for more abstract thinking? If so, are the great apes capable of transitive inferences in a social situation but not for abstract properties?

Another big question concerns consciousness. Francis Crick and Christof Koch galvanized the scientific community by daring to suggest — correctly, I believe — that the nature of consciousness is a tractable scientific question. But I disagree with their specific view that there are "consciousness neurons" (I suspect they were just being provocative in proposing the existence of such neurons). I think that consciousness arises, not from individual neurons nor from the entire brain, but rather from small specialized circuits unique to — or very highly developed in — humans which allow the brain to create an explicit 'metarepresentation' of sensory representations created at earlier stages in the information-processing pathway (which we do share with lower primates). This is accompanied by a sense of 'agency' and self and qualia, of juggling symbols off-line entirely in your brain and, especially, by that feature which we consider uniquely human — knowing *that* you know or *that* you perceive (qualia), or that you don't know.

These abilities are all closely interdependent in a way that we don't yet clearly understand. What I'm calling the metarepresentation bears an uncanny resemblance to the 'homunculus' — but unlike the homunculus it does not lead to an endless regress. It bears the same relationship to the earlier sensory representations as the latter do to external world events. Its purpose is to create abbreviated representations *of* representations highlighting certain aspects to create tokens that can be used for internal juggling of symbols — 'thinking' — or for communicating ideas to others. Both language and one's sense of 'agency' are involved in this in some way that we don't yet clearly understand.

As I said in my Reith lectures, the brain structures involved seem to be the amygdala, the angular gurus ('abstraction' on the left, 'body image' on the right), the supramarginal gyrus and anterior cingulate cortex ('will and want') and Wernicke's area ('meaning'). Find out how these circuits work and how they interact and you will have figured out what it means to be a conscious human being — just as the structural logic of DNA dictates the functional logic of heredity. Anatomy is destiny, as Freud said.

Will neuroscience have to confront ethical issues? The big ethical dilemma will emerge in 3 to 500 years from now, when a neuroscientist will be able to transplant your brain into a vat in a culture medium — I'm serious — and artificially create patterns of activity that will make you feel like you are living the lives of Francis Crick, Bill Gates, Hugh Heffner and Mark Spitz, while at the same time retaining your identity. Given a choice, would you rather pick this scenario or just be the 'real' you? Ironically most people I know, even scientists who are not religious, pick the latter on the grounds that it is 'real'. Yet there is absolutely no rational justification for this choice, because in a sense you already are a 'brain in a vat' — a vat called the cranial vault, nurtured by cerebrospinal fluid and bombarded by photons. All I am asking you is which vat you prefer — and you pick the crummy one! There is a sense in which this is the ultimate ethical dilemma . I personally would choose the 'real' me, by the way, although I don't know why. Maybe it is a sentimental attachment to my current reality or maybe I secretly believe there *is* something else, after all.

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