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# Gone Haywire

*A neurologist uses case studies to illuminate the workings of the brain.*

By **MICHAEL E. GOLDBERG**

**W**hen Newton described the mathematics of motion he provided the philosophers of his day with a stunning insight: that the universe obeyed physical laws and could be understood as a great clock. A similar revolution is underway in modern neuroscience: in the late 20th century we can begin to imagine for the first time that the human mind can also be understood as a machine. Ultimately it should be possible to write a physics of human consciousness.

Not yet. But what we do know is that some human behaviors and perceptions that seem mystical, magical or crazy arise from failure of specific areas of the brain. In "Phantoms of the Brain," Dr. V. S. Ramachandran, a professor of neurology and psychology at the University of California, San Diego, and Sandra Blakeslee, who reports on science for The New York Times, describe Ramachandran's experience with patients whose clinical problems provide insight into the workings of the brain. Ramachandran is more than a describer of fascinating clinical syndromes. He is attempting to understand why brain damage can make a young man think his parents are impostors, or a woman with a stroke laugh uncontrollably; how a man with a stroke can be unaware that his left side is paralyzed, or why certain types of epileptic patients have intense religious experiences.

The phantoms of the book's name are those sensed by amputees who have vivid feeling, even pain, in limbs they know are gone. Ramachandran uses those sensations to understand how the brain, and by extension the human being, feels the sense of touch. Most of the brain is connected not to sensors (like the



skin, the ear or the eye) that measure the world, but to other parts of the brain representing that world. Consider your telephone. You speak, and the telephone changes the voice's sound waves into an electrical signal that passes through relay stations, which pass on electrical signals, not sound waves. Ultimately, the electrical signals become sound again in your listener's phone.

The brain uses a network of connections in a similar way. In our skin, the nerves that provide our sense of touch relay their information to nerve cells, or neurons, in the spinal cord. That information is then relayed through neural centers until it reaches the cerebral cortex, where the body surface is mapped out in a pattern resembling a little human (the "homunculus"), with a discrete area of brain representing each discrete part of the skin. When someone kisses your cheek, neurons in the area of cortex representing the cheek become active, and presumably other parts of the brain interpret that neural signal as a touch on the cheek. Drawing on the extensive literature on animal experiments in neuroscience, Ramachandran gives a plausible solution to the puzzle of why amputees feel phantom limbs. Years ago, in order to understand how the brain adjusts when its connections to the world are damaged, Dr. Edward Taub, now at the University of Alabama, severed the sensory nerves leading from one arm in several rhesus monkeys. The monkeys became a cause celebre in the animal rights movement. After years of legal entanglement, they were finally studied by Dr. Tim Pons at the National Institute of Mental Health, who discovered a change in the cortex area that had represented those limbs. He studied neurons that should have responded to touch on the arm but could not because no information from the arm could reach the brain. These neurons were not silent, though. They now responded to a touch on the face.

That work excited and inspired Ramachandran. He blindfolded a patient with a phantom arm and then touched his face. The man felt the touch both on his face and also on his phantom arm. Ramachandran realized that when he touched the patient's face, he excited the central representations of the arm and the face, just as the signals from nerves in the face had excited the central representations of both the arm and the face in the monkeys' brains. The patient reported two simultaneous sensations: one on the face and one on the missing limb. Although the arm was gone, its handprint in the brain was not.

In his final chapter, "Do Martians See Red?" Ramachandran goes beyond perception and attacks the toughest problem in neuroscience: consciousness. He sets out the problem eloquently: You and I both know what red is, but you will never know the quality of my experience of red. A color-blind person will never even intuit how long-wavelength (red) light gives us that glistening matador's cape, bloody sunset, succulent cherry thrill. The technical philosophical term for such sensations is "qualia," what a person subjectively adds to the scientifically measurable aspects of an object. Ramachandran posits that consciousness arises from the perception of qualia, which, he says combines stable input (the wavelength of red light), choice of interpretation (the cherry or the sunset) and short-term memory (red reminds me of the

sunset). He suggests that a patient who can see only black and white would see red if his brain were stimulated in the right place -- but would that person see Ramachandran's red? Or my red? Ramachandran even postulates that consciousness is the ability to process qualia and that it lies in a specific brain area.

Consciousness must also represent a self. Dualists carefully distinguish between the brain that controls perception and movement, and the self (or, more theologically, the soul) served by those perceptions and actions. Ramachandran does not. He describes several aspects of the self: for example, a passionate self that colors perceptions with emotion, and a mnemonic self that has lived and remembered your life and processes current experience in relation to your past. Underlying this catalogue is the breathtaking assertion that even the self is physically comprehensible.

Here he fails, simply because neuroscience has no clue yet how to render the self concrete, to look at the printout of a scan or put an electrode next to a neuron and say, "Here it is." But it is a noble failure. The book is enthralling not only for its clear, eloquent descriptions of neurological phenomena, their relationship to physiological mechanisms and their integration with philosophy of mind, but also for its portrait of Ramachandran, the enthusiast in search of the secrets of the human mind. "Phantoms in the Brain" is about both the brain and V. S. Ramachandran, and he is a splendid subject indeed.

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