Section Editor
Michael H. Brooke, MD

Of Minds and Maps

Anthony Adamo, DO

Address correspondence and
reprint requests to Dr. Anthony
Adamo, Nassau-Suffolk
Neurology, P.C., 400 West Main
Street, Suite 222, Babylon, NY
11702
adamofamily@juno.com

The history of neurology can be viewed as the history of creating maps. In the 19th century, phrenologists tried to explain personality traits by developing a topography of cranial bumps. This now-debunked idea paved the way for an important neurologic tenet—the localization and specification of brain function. Paul Broca and Carl Wernicke used this principle and began mapping out the mind over a century and a half ago, showing that the unique human ability of language is grounded in specific physical structures of the brain. This began a kind of “Copernican” revolution in the study of brain and mind. We could finally begin to view the mind as a manifestation of the inner physical machinations of the brain and not some mysterious Cartesian “ghost in the machine.”

As a neurology resident I remember being told the classic aphorism “God must be a cartographer, for the brain is full of maps” by a gray-haired pensive neuropathologist. He was not making a theological proclamation but a scientific point. Retinotopic maps guide the visual cortex, tonotopic maps are found in Herschel’s gyrus of the auditory cortex, and somatotopic homunculi inhabit our motor and sensory cortices. Confronted with the intimidating task of slicing and dicing this three-pound enigma in the neuropathology laboratory, it was reassuring to have map and atlas in hand.

Like the ancient ritual of trepanation, we would cut out bone flaps to remove the glistening matter. Under the harsh fluorescent laboratory lights, the oozing brain fluid seemed luminous. Many of the brains we dissected had belonged to walking and talking people just days before the autopsies, sad victims of suddenly ruptured cerebral aneurysms and unexpected cardiac arrests. Holding a fresh human brain in your hands that just a few days ago was thinking and feeling, one cannot help but be astonished over the fact that a hundred billion jelly-like neurons with their hundred trillion connections somehow manage to create memory, emotion, language, a sense of personal identity, and—most mysterious of all—consciousness.

Ultimately, a map is a metaphor constructed by the mind to explain itself. Aristotle viewed the mind as a tabula rasa upon which nature and experience write their story to create our picture of reality. Many

centuries later Sigmund Freud created a tripartite model of the mind, dividing it into unconscious, pre-conscious, and conscious levels. In the past half century, another triune model of the brain became popular, this one looking at the brain in terms of its evolutionary history and dividing into a reptilian brainstem, limbic system, and neocortex.

Most recently, more technological models have prevailed, likening the CNS to the Internet or the most ubiquitous model, the computer. In this modern view, the brain is supposed to be a glorified Turing machine processing information according to computational rules and producing a mental simulation of the environment that we interact with. But our brains do not just record and manipulate data, they imbue meaning into everything we see, hear, touch, and feel. All our models and metaphors are ultimately impoverished because they can only vaguely signify the enormous complexities of the brain.

Like every student of the brain, I have spent countless hours memorizing and learning maps of the cerebral cortex, interconnections of the basal ganglia, neurotransmitter pathways, and the myriad anatomic tracts that span the brain like so much gossamer. The most memorable map of all, however, was one that was held up to my face one midnight by a desperate mother, almost too grief-stricken to speak.

It was a bright autumn morning when this mother’s daughter, Mary, was walking to school with two of her friends. All three were seniors in high school and perhaps their conversation centered around topics like the upcoming senior prom, college acceptance letters, and boyfriends. As the girls crossed the street to their school, Mary was struck by a speeding van, her body sent hurling six feet into the air and crashing down on the hard pavement, her friends screaming in horror. She was hit with such momentum that her school backpack was later found three blocks away.

I first saw Mary in the bright fluorescent day-glow of the intensive care unit. With a brain full of blood, she was in a deep coma on a mechanical respirator. As the days passed, it became clear that Mary could only muster the most primitive brainstem reflexes.

Her mother kept a constant bedside vigil. One evening, clearly exasperated over some minor nursing care issue, she approached me with a book in hand. "Where is my daughter's mind?" she angrily asked, opening her book in front of me. The thick volume appeared to be a college neuroscience textbook. She opened it up and turned to a page containing colorful diagrams of the brain in cross-section. She gestured toward the pictures. "Does she have any memory, does she feel any sadness, does she know that I am here with her?" These questions were not philosophical ruminations but rather a mother's desperate attempt to comprehend the enormity of this unbearable tragedy.

I gently closed the textbook. "You must understand," I whispered, "the damage is pervasive, the brain and brainstem have all suffered irreversible injury." "But what about the thalamus and the reticular activating system? I've read that they're very important for the consciousness," she whispered back to me. Her question, I think, was rhetorical. She knew that the answer she was looking for could not be found in the esoteric language of neurology.

Her somber question "Where is my daughter's mind?" echoed in my mind during the drive back home that night. Do we have any brain maps that can identify where consciousness, self-awareness, or the elusive "I" that narrates our personal history can be found? Not yet. There is no single master control center that mediates consciousness or the self. When it comes to language and memory, this problem may not be as intractable. We know that written and spo-

ken language ability is lateralized in a dominant hemisphere for all humans. Language is a product of several distinct and interconnected areas of the brain and we know that the temporal lobes and hippocampi are crucial for memory storage. Indeed, we now have intricate maps elucidating both structure and function, derived from elaborate imaging studies. But there is no telltale glow on functional MRI that divulges the presence of a center that harbors consciousness or personality identity.

So where does the mind go when the brain is destroyed? Religion has always upheld the idea of an eternal and immutable soul and perhaps this idea comforted Mary's mother. But such solace cannot be provided by neurology, where consciousness and the self must be explained, if ever, in the lexicon of science.

By the time I arrived home that evening, Mary had suffered her second and final cardiac arrest. I thought to myself that somehow I should have been more eloquent, more empathetic, in this tragic circumstance. Without turning to religious symbolism, however, the best I could ponder was this. Mary now exists only as an encoded memory deep in the brains of her loved ones, a kind of virtual reality figment that can be played over and over again. But of Mary's mind, it is lost forever. Of course, I could not bear to say this to Mary's mom. But I really did not need to. With the neurology textbook in hand, she realized, as I did, that some of our most detailed and precise maps are woefully inadequate.

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