Imagine you are an astronaut, untethered from your safety line, adrift in space. Your damaged radio lets you hear mission control’s repeated attempts to contact you, but your increasingly desperate cries of “I’m here, I’m here” go unacknowledged—you are unable to signal that you’re alive but injured. After days and weeks of fruitless pleas from your loved ones, their messages cease. You become lost to the world. How long do you keep your sanity when you are locked in your own echo chamber? Days? Months? Years?

This nightmarish scenario is vividly described by British neuroscientist Adrian Owen in his upcoming book *Into the Gray Zone* (Scribner). Taking my evening bath while dipping into its opening pages, I only put the book down after finishing hours later, with the water cold. The story of communicating with the most impaired neurological patients at a greater distance from us than an astronaut lost in space is told by Owen in a most captivating manner.

A professor at Western University in Ontario, Canada, Owen pioneered brain-imaging technology to establish what islands of awareness persist in patients with severe disorders of consciousness. These people are bedridden and seriously disabled, unable to speak or otherwise articulate their mental state following traumatic brain injury, encephalitis, meningitis, stroke, or drug or alcohol intoxication. Two broad groups can be distinguished among those who do not quickly succumb to their injuries.

Vegetative state patients, in the first group, cycle in and out of sleep. When they are awake, their eyes are open, but attempts to establish bedside communications with them—“if you hear me, squeeze my hand or look down”—meet only with failure. These patients can move their eyes or head, swallow and yawn but never in an intentional manner. Nothing is left but surviving brain stem reflexes. With proper nursing care to avoid bedsores and infections, these individuals can live for years.

Consider Terri Schiavo, the woman in Florida who lingered for 15 years in a vegetative state until her medically induced death in 2005. Given the very public fight between her husband, who advocated discontinuing life support, and her parents, who believed that their daughter had some measure of awareness, the case caused a huge uproar. It was litigated up and down the judicial chain and eventually landed on the desk of then president George W. Bush. Despite continued legal wrangling to keep Schiavo alive, her husband ultimately prevailed in his wish to have his wife taken off life support.

Medically, her case was uncontroversial. She had brief episodes of automatisms: head turning, eye movements and the like but no reproducible or consistent, purposeful behavior. She showed no brain waves on electroencephalographic scans, indicating that her cerebral cortex had shut down, confirmed by her autopsy.

Given helicopters and modern emergency room medicine, her case is not an isolated one. With some rare exceptions, vegetative state patients are a modern phenomenon: these individuals depend on rapid, massive surgical and pharmacological intervention. Exact numbers are difficult to arrive at because there is no central registry and many of these patients are relegated to hospices and nursing homes or are cared for at home. Estimates of vegetative patients in the U.S. range from 15,000 to 40,000.

In a more ambiguous category are minimally conscious state (MCS) patients, who have some ability to communicate their internal state but usually only in a minimal or inconsistent manner. They may smile or cry in appropriate emotional situations, vocalize or gesture on occasion, track salient objects with their eyes, and so on.
Properly diagnosing vegetative patients remains a great challenge for clinicians. Unlike comatose patients, who may look dead to the naive viewer, vegetative patients are clearly alive. To loved ones desperately searching for any signs of recognition and recovery, they appear to be making an attempt to communicate. Who is to say that there may not be remnants of awareness of pain and distress in these patients living in a murky zone between fleeting consciousness and nothingness? Or, worse, maybe a full-blown stream of consciousness but an inability to cry out for help?

Enter modern neurotech, with its armamentarium of brain scanners. A slew of experiments had shown already in the late 1980s that brain activity could be reliably evoked in healthy volunteers by merely thinking—silently counting backward or imagining playing soccer. Such experiments are a spectacular confirmation of pure mind affecting matter, for example, thinking about kicking a soccer ball without moving a single muscle induces enhanced blood flow to that part of the brain involved in planning the bodily action.

Owen and his collaborators—in particular, Steven Laureys of the University of Liège in Belgium and Melanie Boly, now at the departments of neurology and psychiatry at the University of Wisconsin–Madison—developed two tasks that reliably evoke brain activity in two
distinct cortical regions that can be seen with functional MRI.

The first task for volunteers in the scanner was to think about playing tennis, hitting a fictitious ball back and forth across an imaginary net. The resulting scans showed increased hemodynamic activity (more cerebral blood flow and nutrient supply) to their supplementary motor area (SMA) at the top of the head. The second task— to mentally walk from room to room inside their house— sparked activity in the middle of the brain. One activity could easily be distinguished from the other. Because this type of willful and sustained mental effort goes hand in hand with vivid conscious experience (“I can see my right hand gripping the racket and swinging it”), it is taken to be as good a marker of consciousness as any.

The question Owen and his team then effectively posed to minimally conscious patients was the extent to which these individuals, behaviorally unresponsive to most requests put to them, could regulate their brain activity when asked to carry out one or the other imagery task repeatedly for 30 seconds.

Carol, a 23-year-old woman hit by two cars while walking across a road talking on her cell phone, was diagnosed as being in a vegetative state, with substantial damage to her frontal lobes. Yet to the surprise of the clinical staff, she could carry out both mental tasks, willfully up-regulating activity in either her SMA or PHG, depending on which task was requested. Carol therefore appeared to have some level of consciousness and cognitive control left, even though none of it could be observed with standard clinical tests.
Over the next several years a study of 54 patients with consciousness disorders at two clinical centers—in Cambridge, England, and in Liège—confirmed the basic finding. Five patients could willfully modulate their brain activity in a controlled manner. Of these, four were among the 23 study patients that had been labeled vegetative. This observation suggests that perhaps 20 percent of vegetative state patients are misdiagnosed—they are at least somewhat conscious, a finding that aligns with some previous estimates. Subsequent bedside testing confirmed that a few of the patients were indeed in a minimally conscious rather than a vegetative state. Given the hectic pace of modern hospital settings, it is easy for the overworked care staff to miss the occasional subtle life signs of somebody locked inside their damaged brain. (Such a case—the story of Maggie—was evocatively described by neurologists in the November/December 2016 issue of Scientific American Mind.)

Two of the five patients in the English and Belgian study who succeeded on the imaginary tasks in the scanner nonetheless remained behaviorally incommunicado. That is, from the outside, they appeared alive yet without a mind. Only their brain-imaged responses revealed that they retained a conscious voice.

Surprisingly, of the 31 minimally conscious patients in the study, only one could manage the imaginary tasks. An editorial accompanying the publication of the article reporting these results in the prestigious New England Journal of Medicine cautioned that such willful manipulation of brain activity was seen only in a few patients and does not imply the existence of an internal stream of thought of the kind you and I experience throughout the day. Fair enough. But what is remarkable and a potential game changer for those patients is that this technique was adapted by Owen and his colleagues—in particular, Martin M. Monti, now a psychology professor at the University of California, Los Angeles—

HAUNTINGLY INCONCLUSIVE, AND THE EXPERIMENT THEN ENDED.

Owen successfully repeated this communication task a couple of years later with Scott, a young man involved in a traffic accident. Declared a vegetative state patient, Scott was able to answer questions put to him—“Are you in any pain?” was one, to which he replied no.

For a variety of practical, technical and scientific reasons, communicating via a string of yes or no queries in a magnetic scanner is not routine clinical practice for brain-injured patients. It is not only demanding of equipment, people and time but also prone to generating incorrect answers.

Many patients are unable to drive activity in the SMA or PHG or can do so only erratically. Procedures that work perfectly well in healthy research subjects fail when tested in those whose brains have undergone massive changes because of disease or trauma. Carrying out an imaginary motor or navigation task is cognitively less demanding than answering questions using one of these two tasks, which explains why only a handful of consciousness-impaired patients have successfully communicated in this manner. The majority remain sadly lost to the world. M

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- Into the Gray Zone: A Neuroscientist Explores the Border between Life and Death. Adrian Owen. Scribner, 2017. From Our Archives