Mrs. K. questions who she really is. Her family, her career, her entire life seem pointless. She feels anxious and broods. She sometimes screams at her children for no reason and then feels guilty. She has toyed with the idea of suicide. In contrast, Mr. M. believes that he possesses extraordinary gifts. He spends long nights writing down grandiose plans to save the world and sends his manuscripts to numerous publishers. Despite heaps of debt, he buys an expensive sports car, anticipating success. He has never felt more confident. These patients suffer from different mental illnesses—Mrs. K. is depressed, and Mr. M. is manic—but they both hold highly distorted views of themselves.

It is more than just sage advice to “know thyself,” as Heraclitus advocated in the fifth century B.C. A realistic self-image is a hallmark of a healthy mind. Ancient Greek philosophers speculated that the psyche determines behavior. Since then, numerous studies have shown that people

Me, Myself and I

Although people change throughout their lives, most hold a steady view of who they are. How does the brain maintain a sense of self? By Uwe Herwig

with a faulty self-image tend to have high levels of anxiety, defensiveness, self-doubt and narcissism. Relationships, careers and happiness suffer when reality doesn’t match who we think we are.

How does a person’s self-image come unglued? Neuroscientists have long searched for the origins of self in the brain. Thanks to advances in imaging technologies, they have made progress in recent years, but the “I” remains hard to pin down. For one thing, it is the product of a distributed array of brain structures. More confounding, the “I” is a moving target: many factors—from a person’s upbringing to major life events—continually shape the self. This shifting sense of self does not only derive from the narratives we construct to make sense of our lives. It is also biological: experiences generate new brain cells and neural pathways.

Yet despite all this wiring and rewiring, the mind typically manages to maintain a consistent self-portrait. Subjectively, we perceive the “I” as an unchanging framework—a steady reference point for ordering our thoughts, emotions and experiences. Moreover, the “I” provides clear boundaries—we make sharp distinctions between internal and external events. We regard thoughts, feelings and memories as our own; they belong to us. And even when we empathize with others, we know very well whose mental states belong to whom. How does the healthy brain maintain this unwavering, well-defined self? And to what end? Why aren’t we simply biologi-
The Layers of Self-Awareness

We begin to establish a sense of self shortly after birth. From three to five months old, babies start to gain control over their movements; they recognize themselves in the mirror at about 18 months; they grasp concepts such as “I” and “mine” at about age two; and they readily describe their own feelings at about three years old. Once children reach elementary school, they make friends and begin to draw comparisons, which further inform their self-image. Teens and young adults continue to expand their personal identities as they practice progressively nuanced social skills.

Neural connections form in step with these developmental stages. A newborn’s brain exhibits relatively few of the trillions of synaptic linkages it will ultimately possess. By a child’s sixth year, however, his or her brain has experienced an explosive growth in its connections. Over time, experience consolidates and prunes these associations: unused links disappear, while significant or frequent experiences reinforce other channels. As this fine-tuning takes place, we become increasingly well acquainted with ourselves—from our basic biological urges to deep-seated desires and dreams.

The sense of self has multiple components. To begin with, there is the ability to recognize one’s own face and body and to know what those body parts are doing at any given moment. There is also the sense of ownership—you perceive your body as belonging to you—and the sense of agency: you feel responsible for your own movements and actions. And at the highest level, there is the awareness of one’s own emotions and the ability to link disparate life experiences to a stable self-image.

Brain malfunctions can disrupt any of these processes. We have seen how depression and mania can derail a stable self-image, but other aspects of self are equally vulnerable. There are people, for example, who function pretty much normally except that they do not recognize themselves in a mirror. Others have trouble tracking the movements of their bodies. Some may even disown one of their limbs [see “Amputee Envy,” by Sabine Mueller; Scientific American Mind, December 2007/January 2008].

In the mid-1990s neurologist Antonio R. Damasio, then at the University of Iowa, distilled the self’s multiple layers into a three-part hierarchy. The lowest level, which Damasio calls the proto-self, corresponds to a simple, neural representation of the body. This proto-self oversees basic physical functions such as metabolism, body temperature and circadian rhythms. We are not conscious of the proto-self unless problems arise, eliciting attention from the core self (the intermediate level), which generates our immediate cognizance of the here and now. At this level of awareness, signals from the body give rise to nonverbal impulses—feelings of hunger, sadness or cold. The autobiographical self, Damasio’s top layer, enables us to evaluate our impulses rationally—referencing earlier experiences and current goals—and to guide our behavior in a targeted way.

These three layers of self emanate from increasingly sophisticated processing centers in the brain. The proto-self is associated with the brain stem and the hypothalamus, structures found at the base of the brain near the spinal cord. The core self enlists
Thinking before You React

What is self-awareness good for? It helps people recognize and manage fear, anger and other potentially destructive emotions. Studies show that when people distance themselves from upsetting feelings, the rational parts of their brains (light green) tamp down emotional ones such as the amygdala—and they feel better.

The Tickle Conundrum

To explore the self in the laboratory, scientists often use a two-part model instead of Damasio’s triumvirate. On a practical level, it makes sense to divide the “I” into its physical and cognitive components. The physical self is where we feel our own body, thanks to sensory feedback from the skin, joints and abdominal cavity. This input generates interoception—our awareness of pain, temperature, itching and hunger, among other internal sensations. The cognitive self is where we recognize and reference ourselves in the world.

Interoceptive awareness appears to depend heavily on the anterior insula, a brain structure that is buried deep within the cerebral cortex. In 2004 Hugo D. Critchley and his co-workers at University College London conducted an experiment in which they asked people to estimate their own heart rates as they lay in a magnetic resonance imaging machine. The autobiographical self, meanwhile, relies on linguistic abilities that only humans possess. Accordingly, it employs speech and memory centers in the hippocampus and Broca’s area, as well as parts of the prefrontal cortex. Many of the areas related to the self are found along the brain’s midline, where its two hemispheres meet.

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Many creatures, not just humans, have a basic level of self-awareness. They need it to survive.

The study subjects listened to their heartbeats through a headset—either in real time or delayed by half a second—and then had to decide which version was their actual pulse.

The results showed that greater activity in the anterior insula corresponded to greater accuracy on the task. In other words, subjects who were more in tune with their own heartbeat made greater use of their insula. Furthermore, people who were particularly sensitive to physical sensations—for instance, they were more apt to notice a dry mouth or abdominal pressure—tended to have more insular gray matter than is normal. Other research has implicated heightened interoceptive awareness in panic and anxiety disorders. In such conditions, behavioral dysfunction may relate to faulty readings of the self.

The cognitive self, in contrast, seems to reside in the medial prefrontal cortex—located behind the eyes on the inner surface of each hemisphere. In 2006 Joseph Moran, now a postdoctoral fellow at the Massachusetts Institute of Technology, and his colleagues asked healthy test subjects to judge how well a string of adjectives applied either to themselves or to people they knew. Only when the participants related the traits to themselves did functional MRI scans of their brains show increased activity in the medial prefrontal cortex. Interestingly, this increase occurred regardless of whether the adjective described a positive or a negative attribute.

The brain also contains specialized circuits for distinguishing between self-generated and external stimuli—which explains at least in part why we cannot tickle ourselves. To discover which brain regions normally make this self/nonself distinction, Knut Schnell of the University of Bonn in Germany and his colleagues asked 15 men to play a simple racing video game. Periodically, the computer would take over the steering function, and the men had to monitor, as they played, whether they or the computer was controlling the car.

Functional MRI scans revealed that as the participants observed their own actions, they activated a network in the prefrontal cortical region and in the inferior parietal lobe. The prefrontal cortex, in its role as the brain’s command center, plans our actions and sends instructions to whatever parts of the body are required. At the same time, it sends a copy of its instructions to parts of the parietal lobe, which monitor our movements and anticipate the corresponding sensations. The brain takes special notice if our experience does not match the parietal lobe’s predictions—say, the car turns left when we turn the wheel to the right. In this way, we filter out self-generated stimuli and perceive external input—sensations we have not predicted—more urgently.

Related brain structures are responsible for self-referential thinking, according to studies by Tilo Kircher of the University Psychiatric Clinic in Marburg, Germany, and Steven M. Platek of Georgia Gwinnett College in Lawrenceville, Ga. Activity in the cingulate cortex, as well as the premotor, insular and somatosensory cortices, increased when test subjects looked at photographs of themselves. But when the participants looked at photographs of other people (some of whom they knew, others whom they did not), these brain areas either did not light up or lit up only faintly on the MRI scanner. Moreover, cingulate and insular areas fire even when someone merely expects to see his or her own face, as Annette B. Brühl of the Psychiatric Univer-
The Emotion Connection

Why does the brain contain mechanisms for picturing ourselves—where we are, what we are doing, who we are and how we feel? The simple answer is that many creatures, not just humans, have a basic level of self-awareness; they need it to survive. An animal that can’t tell what is itself and what is the world is virtually helpless. It can’t react or coordinate its movements. It can’t make the critical inferences about cause and effect (“When x happened, I felt y”) that enable it to find food and avoid harm.

But for animals, like humans, that inhabit a complex social universe, the autobiographical self offers another advantage: the opportunity to regulate feelings. We live in a sea of emotionally significant stimuli, from the neighbor’s snapping dog to an unexpected hug, and it is vital to our mental and physical health that we respond appropriately—which may involve replacing a knee-jerk emotion with a more reasoned view. Once we bring charged emotions into the realm of awareness, we can neutralize their stressful physiological effects, such as an elevated heart rate, increased blood pressure, sweating and trembling.

In 2007, building on previous work by Kevin N. Ochsner of Columbia University and James J. Gross of Stanford University, my colleagues and I explored the neural basis of a technique known as cognitive reappraisal that depends, by definition, on self-awareness. Using this method, people learn to reflect on a situation and reframe it in a positive way.

Our team from the Psychiatric University Hospital Zurich, the University of Zurich in Switzerland and the University of Ulm in Germany conducted a two-part study. In the first part, we told 18 healthy test subjects that we would present them with either unpleasant or emotionally ambiguous pictures—possibly happy, possibly not—as they lay in an MRI scanner. We asked them, as they anticipated the pictures, to reassure themselves that they were perfectly safe no matter what the images showed.

In the second part, we told another 16 subjects to anticipate these images but did not instruct them to manage their expectations in any way. The people from the first group who successfully used cognitive reappraisal to stay calm showed increased activity in the prefrontal cortex and weaker activity in the amygdala—they had apparently prompted the brain to use its decision-making powers to buffer emotional responses. And the strategy worked even when people did not know what was coming.

Meditation techniques that enhance mindfulness—purposeful, attentive and nonjudgmental awareness of the moment—seem to prime the same circuitry. In a recent study we asked subjects either to be aware of their current emotions or to think about themselves. The pure focus on an individual’s emotional state reduced activity in the amygdala, creating a calming effect.

As imaging technology continues to develop, it is possible that brain-scanning devices might someday provide real-time feedback to people as they meditate, enabling them to train their brain to be more mindful. And in the near future scientists may be able to study whether this kind of feedback might be used to help people master emotional self-regulation. People such as Mrs. K. and Mr. M. would likely derive benefit. Research makes it clear that our self-image is a product of our brain. By honing our powers of self-reflection, we can actively work to keep our self-image in step with reality.

(Further Reading)