INTRODUCTION

It may be surprising that it has taken *Homo sapiens* centuries of reflection before realizing that the brain is the source of thought and awareness, centuries to allow the brain to usurp the organs—the heart or the liver (and its bile)—that had always been considered the centers of emotions. The Egyptians took the brain out of their mummies because they considered it to be merely a radiator. Aristotle, too, thought that the brain served to cool blood that was overheated through an emotional agitation of the heart, a concept that we find in the French expression *perdre son sang-froid*—"to lose one's cool." And yet the brain being so highly protected by the bone of the skull should have put people on the right track much earlier: it is clearly not by chance that nature provided the seat of our nervous system with such armor. Of course, traces of trephination discovered in prehistoric remains suggest that some curious observers had perhaps begun to suspect the truth. But for centuries the skull was associated more with death and its representations than seen as a container sheltering the organ of our thoughts.

And so it wasn't until the relatively recent age of the advent of anatomy, then surgery, that people dared to examine the brain, and to begin to study it. Much of our current knowledge comes from the work of Paul Broca on language in the mid-nineteenth century; from dissections of the brain of deceased patients; and from observing the brain of patients awake during neurosurgical interventions. Understandably, the possibility of seeing the brain of a living patient, let alone the brain of completely healthy subjects, for a long time remained an inaccessible dream. Only science fiction novels and films dared to suggest that one day it would be possible to have direct access to the contents of our thoughts by observing the human brain.

But this didn't take into account the progress that had been made in the realm of physics. Atoms had been discovered, and mysterious rays, such as x-rays or those emanating from natural radioactivity, had been demonstrated. Following these discoveries theoretical and experimental physicists at the beginning of the twentieth century in a few years put into place physical and mathematical models to explain such strange phenomena and to account for the infinitely small. And so quantum physics was born, a discipline that explained the behavior of atoms and particles, the ultimate components of matter. Armed with these powerful theoretical tools, physicists were able to go beyond what was available in nature: radioactivity became artificial, atomic systems were mastered to produce a new, very powerful light—the laser—and, based on an equivalent principle, radio waves following the magnetization of certain atomic components. Engineers consolidated all these discoveries into developing apparatuses, such as x-ray tubes, enabling them to be reproduced on demand in well-controlled conditions, and to be used for various applications.

This is how physics joined the field of medicine, and in particular the field of medical imaging. The rays and particles discovered by physicists in fact had the ability to travel through our bodies, providing shadows of the structures they had traversed. Radiology made its debut as a medical specialty, and then came "nuclear" medicine. On a medical level, such images of the interior of the human body constituted an initial revolution, but those images remained fairly rudimentary, the organs were more "guessed at" than truly observed. The second revolution came with the marriage of physics and computer science at the end of the last century. Sensors of rays and particles became highly sensitive, and the computer was able to enhance that sensitivity, showing for the first time details of internal organs, and in particular of the brain inside the skull. "Neuroimaging" made great strides in the last quarter of the twentieth century, when it became possible to observe easily and without risk the brains of sick or healthy subjects, including that of a fetus in its mother's womb. Neuroimaging then became functional, revealing the workings of our brain while we are thinking, sometimes enabling access to the contents of our thoughts, or to the thought processes of which we are unaware.

How did neuroimaging become an incomparable method both for the neurosciences and for medical practice? What of our brain, and its functioning, do we really see in these images? How can we detect the signs of illnesses, both neurological and psychiatric, read our thoughts, gain access to our unconscious? These are the questions we will attempt to answer here. After recalling what our brain is, exactly, and why the concept of imaging is particularly adapted to it, our travels will lead us progressively from the instrument of imaging to what it enables us to see. For neuroimaging is essentially multidisciplinary: physics, instrumentation and engineering, software and sophisticated calculation processes enable that which otherwise would remain invisible to appear before our eyes; the biological sciences contribute, as well, whether it be molecular or integrative biology, neuropsychology or the cognitive sciences, neurology, psychiatry . . . The contributions of these disciplines are most often presented in their historical context, in order to show how science is made and unmade, depending upon human passions or dramas, Nobel Prizes or frustrations. Some chapters are more technical (chapters 1 and 3), but the chapters that follow them provide a glimpse into the huge realm of applications. Neuroimaging is well on its way; it has already changed our society and raised ethical questions. How far can it go? And will it enable human beings, themselves, to understand their own brains?