Chapter 1

Introduction

> Probably one of the most important initiatives we have ever undertaken is our support for positron emission tomography (PET), an intriguing new research technique. . . . With PET we will be able to examine what happens functionally, in the living human brain, when a person speaks, hears, sees, thinks. The potential payoffs from this technique are enormous.
>
> —Dr. Donald B. Tower, Director of the National Institute for Neurological and Communicative Disorders (from the NIH Record, 1980)

> In science, just as in art and in life, only that which is true to culture is true to nature.
>
> —Ludwig Fleck

Sitting in a paneled conference room at the University of California, Los Angeles, with framed brain images on the wall, I am talking with Dr. Michael Phelps, one of the fathers of positron emission tomography (PET) scanning (figure 1.1). As I explain my project on the history and anthropology of PET brain images, he interrupts to turn the question back to me:

PHELPS: What is it? If I am just an ordinary person and I ask you, "What is PET?"

DUMIT: It is a device that is like a CT [computed tomography] scanner but isn't. With PET, you take some molecule or drug that you

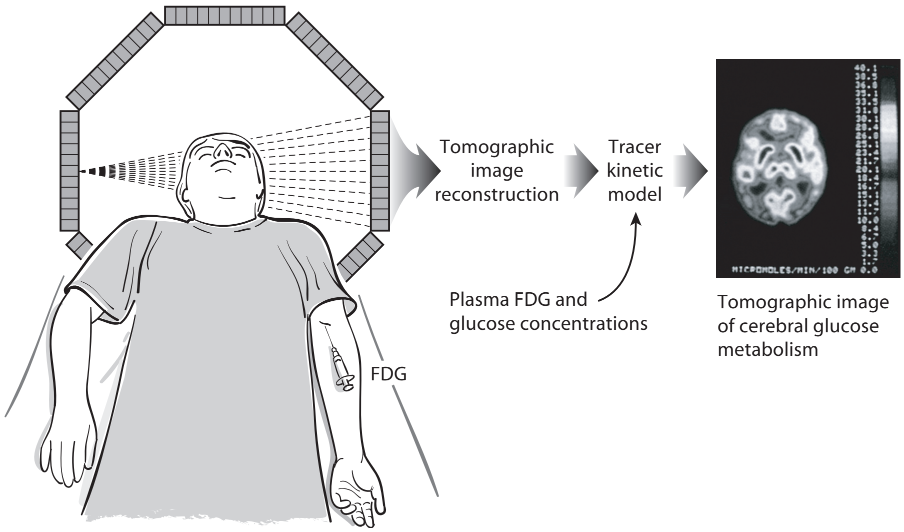

FIGURE 1.1. Principle of positron emission tomography (PET) using example of ^{18}F-fluorodeoxyglucsoe (FDG) to image glucose metabolism in the human brain. (Michael E. Phelps 1991)

want to image—water or glucose, for example. You attach a radioactive isotope to it and inject it into your body, and what you image is where the tagged molecule or drug goes. You image the radioactivity through time; you capture it with a ring of detectors. What you get is an image of a slice and are able to reconstruct where the radioactivity is in one slice that gives a cross-sectional view of where something is through time. You can use it to find out where in the body and with what amounts the molecule is.

PHELPS: You know, another way to approach the explanation is to forget about PET initially and focus on the problem: That is to be able to take a camera and just watch. Inside the body is all this biology that we know is going on. You take food in, you eat it, and it becomes nutrients for your cells.

Your body looks like it is a physical, anatomical substance, but inside there are all kinds of cells that are metabolizing things, or moving around and doing things, signaling to each other. We'd like to be able to watch this action. That is the objective. You know the activity is there, and you'd like to be able to build a camera that can watch it. Well, one way to do that is first to say, "Well, if I was really little, I could go in there, move around, and watch those things." But since you can't go in there, you can send a messenger. So you do that. You say, "Well, I want to look at one portion of this." So you take a molecule that will go and participate in that portion. The molecule will go through that process. You take that molecule and put a source on it that will emit back to you. So you inject it into your bloodstream, and it goes on this journey. It goes throughout your body with the flowing blood, and depending on that molecule, it will go into some organ that uses it. And you have a camera and can sit there now and watch that molecule, watch it go through the blood supply, go into the brain, go into the tissue of the brain, and actually go through the biochemical process. So you have a camera that allows you actually to watch some of that, watch the biology of the body. So that is really the objective. Forget about the particulars of the instruments. I know that inside this being there is a whole bunch of stuff going on, the biological activity of the body, the body's chemistry. It gives me a way to watch that. This is really what PET does. It reveals to us something that we know is going on inside your body, but that we can't get to. And it does it in such a way that does not disturb the biology of the body's chemistry. This molecule is in such trace amounts that it—the body—goes on about its business. The molecule is apparent to us but transparent to the body.

DUMIT: Like an ideal participant observer.

PHELPS: It is an observer that doesn't disturb you. That is, what happens would happen with or without that observer there. If you are an observer at the presidential conference and bother the president, then you distort what would have taken place had you not been there. But this molecule is given in such trace quantities that it makes no disturbance. Whatever happens would have happened whether you were there or not.

PET scans are generated by an incredibly complex, expensive, and deeply interdisciplinary set of techniques and technologies. An experimental PET brain scanner, including a requisite cyclotron to produce radioactive nuclides, costs about $7 million to purchase. A PET research project also needs the expertise of physicists, nuclear chemists, mathematicians, computer scientists, pharmacologists, neurologists. The aim is physiological: to gain information about the patterns of molecular flow in the body at specific places over a specific amount of time. PET scanning is the solution to the problem of how to follow a molecular substance like water, oxygen, sugar, or Prozac and see where in the body it goes, how much goes there, and whether it stays or circulates out of the area. With the use of a cyclotron, radioactive isotopes of one of the four common biological atoms (carbon, nitrogen, oxygen, and fluorine, the latter standing in for hydrogen) are substituted for the original atoms in the molecule of interest. This radiolabeled molecule functions exactly like the normal molecule. As it decays, the radioactivity is captured by the scanner and reconstructed in a map of the flow rate of the molecule. The result is a "picture" of the molecular flow in the body. This description is, of course, very general and overlooks many qualifications, assumptions, and variables in PET. This description is also not neutral. It will take the rest of the book to explain how each description of PET by different PET researchers is part of an ongoing attempt to define the meaning and purpose of PET and PET images, to make claims of invention and contribution, and to give ontological structure to the brain.

As an anthropologist, I have observed and interacted with various facets of this community for over 3 years, and I feel PET to be an incredibly important and increasingly powerful technique for producing images of living human brains. On the basis of my research, I have identified an area of PET signification that I believe is critical in debates over the roles of PET in the world today: *the visual effect of PET brain images*. By attending closely to PET images, I have chosen the most mobile aspect of PET experiments. These images travel easily and are easily made meaningful. Because they are such fluid signifiers, they can serve different agendas and different meanings simultaneously. While representing a single slice of a particular person's brain blood flow over a short period of time, one scan can also represent the blood flow of a *type of human*, be used to demonstrate the *viability of PET* as a neuroscience technique, and demonstrate the *general significance of basic neuroscience research*.

In this book, we will be exclusively discussing PET *brain* images of mind and personhood, which are the most prominent PET images in the media. However, they are only one small part of PET's usefulness. In addition to imaging the brain, PET is used *clinically* to image the heart, to help determine the ability of the heart to withstand a heart-bypass operation. PET is also extremely useful in whole-body and specific organ scanning to detect different cancer types by using a radiolabeled tracer that is attracted to metastatic and not benign tumors (e.g., it has been approved for Medicare and Medicaid coverage to help stage breast cancer).[1] PET is also used in neurosurgery to identify the precise location of epileptic foci. These other uses of PET are not subject to the same kind of critique we will be applying to PET brain-type images. This is because these other uses of PET can be calibrated directly with their referent. The heart, for instance, can be looked at surgically, and in comparison with the PET image one can learn exactly what signals regularly correspond with different tissue states. But in the case of mental activity and brain-types, there is no corresponding calibration.[2] In spite of decades of research into schizophrenia and depression, for example, there are no known biological markers for either one (Andreasen 2001), though with Alzheimer's disease, we may be close. Thus in many cases, though we can say that PET accurately identifies the location of the radiolabeled molecule in the brain, we cannot *verify* that the additional oxygen flow through the frontal cortex is a symptom of schizophrenia.

Popular Brain Images

The brain scans that we encounter in magazines and newspapers, on television, in a doctor's office, or in a scientific journal make claims on us. These colorful images with captions describe brains that are certifiably smart or depressed or obsessed. They describe brains that are clearly doing something, such as reading words, taking a test, or hallucinating. These brain images make claims on us because they portray *kinds* of brains. As people with, obviously, one *or* another kind of brain, we are placed among the categories that the set of images offers. To which category do I belong? What brain type do I have? Or more nervously: Am I normal? Addressing such claims requires an ability to critically analyze how these brain images come to be taken as facts about the world—facts such as the apparent existence and ability to "diagnose" of these human kinds. Behind our reading of these images are further questions of how these images were produced as part of a scientific experiment, and how they came then to be presented in a popular location so that they could be received by readers like us.

As readers, all of the processes of translation of facts, from one location and form of presentation to another, should be imagined when we critically assess a received fact. We should try to become as aware as possible of the *people* who interpret, rephrase, and reframe the facts for us (the *mediators*). We should also critically assess the structural constraints of each *form* of representation—peer review, newsworthiness, doctor presentations to patients (the *media*). In the case of the brain, these processes of fact translation are caught up in a social history that includes how the brain came to be an object of study in the first place, and what factors—conceptually, institutionally, and technically—were part of its emergence as a fact. When did it first become possible to think of the brain as having distinct areas that can break or malfunction? How and when did the brain come to have "circuits"? How did techniques and technological metaphors like telegraphs and electricity make it possible to pose the problem of brain imaging? In turn, what disciplinary and institutional funding mechanisms were available to make the questions posed answerable?[3] Some human kinds that we are starting to take for granted, such as "depressed brains," require attending to broader social and institutional forces in order to understand how it is that we look to the brain for an answer.

An early appearance in the popular media of brain images can be seen in a 1983 article in the fashion magazine *Vogue* (see Plate 1). Entitled "High-Tech Breakthrough in Medicine: New Seeing-Eye Machines . . . Look Inside Your Body, Can Save Your Life," the piece was accompanied by a simple graphic: three similar, oval-like blobs each filled with dissimilar patterns of bright colors (Hixson 1983). Above each shape is a white word in bold font standing out from the black background: NORMAL, SCHIZO, DEPRESSED. The article does not need to be read to be understood. The juxtaposition of words and images brings home quite forcefully that the three colored ovals are brain scans, and that the three brains scanned are different. These images insist that there are at least three *kinds* of brains. Presumably, these brains belong to different people—who are three different *kinds* of *persons* because their brains are not the same. The cultural and visual logics by which these images persuade viewers to equate person with brain, brain with scan, and scan with diagnosis are also the subject of this book.

Facing the brain images in *Vogue*, there appears to be something *intuitively right* about a brain-imaging machine being able to show us the difference between schizophrenic brains, depressed brains, and normal ones. This persuasive force suggests that we ignore the category question of whether three kinds of brains *means* three kinds of people. How could there not be a difference in these three kinds of brains if there are such differences in the three kinds of people, schizophrenics, depressed, and normals? And after seeing the different brain images, how could one not perceive a difference between these three "kinds" of people? The images with their labels are part of the process of reinforcing our assumptions of difference and making them seem obvious and normal. Rationally, we may still remember that this is a category mistake, a substitution of a small set of scan differences for the universal assumption of differences in kind. Thus, the effect of such presentation of images is to produce an identification with the idea that there is a categorical difference between three kinds of humans that corresponds essentially to the three kinds of brains—or *brain-types*. So we see, too, that in our encounters with brain images we come face-to-face with an uncertainty regarding our own normality and "kinds" of humans that we and others are. Alongside the social and institutional components of brain-fact production, we must face this question of how cultural identification and intuition coincide with these representations of reality so that we are persuaded to take them as true.

What does it mean to encounter "facts" like brain images in popular media? How are "received facts" like these used in other contexts and by other people—in courtrooms, in doctors' offices, before Congress? The labels and stories accompanying the image may be far removed from the careful conclusions of the original scientific journal article, and the news story may include comments deemed "indefensible" by the original researchers. Nevertheless, popularization is not a simple one-way process of corrupting by dumbing down a scientific message. In many cases, the researchers will continue to participate with journalists in constructing these stories because there are not many other ways to get the facts out. Publicity in all of its forms, with all of the transformations it conducts on the facts, is how we come to know facts about ourselves (Myers 1990; Nelkin 1987; Prelli 1989). In any case, like scientists, as scientists, we supplement our knowledge with facts, knowing full well that the facts almost always have qualifications. This does not stop us from incorporating these facts, however, and from assuming them and acting on them (Hess 1997; Martin 1994).

Many researchers have pondered how risks, danger, and stereotypes (notions of human kinds) are best explained in cultural terms. Ranking uncertain dangers, acting in the face of contradictory facts, and imagining human kinds and attributes are culturally and historically variable practices (Douglas and Wildavsky 1982; Gilman 1988). Borrowing a term from psychology and semiotics, we can characterize our relationship to culture as *identification*. Rhetorician Kenneth Burke defined identification as the "ways in which we spontaneously, intuitively, even unconsciously persuade ourselves" (Burke 1966, p. 301). As in analyses of ideology, the rightness of facts seems to emerge from our own experience.[4] This notion of self-persuasion helps us keep in mind both the persuasive action of received facts (e.g., from a magazine) and the *form* in which we often (but not always) incorporate them *as facts*.

We might call the acts that concern our brains and our bodies that we derive from received-facts of science and medicine the *objective-self*.[5] The objective-self consists of our taken-for-granted notions, theories, and tendencies regarding human bodies, brains, and kinds considered as objective, referential, extrinsic, and objects of science and medicine. That we "know" we have a brain and that the brain is necessary for our self is one aspect of our objective-self. We can immediately see that each of our objective-selves is, in general, dependent on how we came to know them. Furthermore, objective-selves are not finished but incomplete and in process. With received-facts, we fashion and refashion our objective-selves. Thus it is we come to know certain facts about our body as endangered by poisons like saccharine, our brains as having a "reading circuit," and our fellow human beings as mentally ill or sane or borderline.

Objective-selves always pull at issues of normality, and with brain scans there is a powerful semiotics of what counts as normal. However, normality can be a variety of things. In the history of science and medicine, Georges Canguilhem has described the many different ways in which the "norm" has been crafted. What is normal has been defined as an average in a population, as a typical member, as an ideal type (Canguilhem 1978). In the case of the PET images in *Vogue*, normal does not necessarily mean "healthy"; it means "nonschizophrenic" and "nondepressed." In other words, if you have a test to diagnose an illness, testing positive for the illness usually means you have it, and testing negative usually means you do not; it does not mean that you do not have *any* illness. The qualifier *usually* must be emphasized, because most tests for biological conditions are not 100 percent accurate. They often have both a false-positive rate and a false-negative rate.

Before we can understand what the labels NORMAL, DEPRESSED, and SCHIZO really mean, we have to know more about how they were defined experimentally. Was NORMAL derived by taking a number of healthy individuals and averaging their brain patterns together? If so, does it matter how many individuals were used, or if they were all right-handed, or all male, or all of college age? Likewise, as critical readers or consumers of depression-industry products and services, we would like to know what criteria were used to select individuals as "depressed." In addition to demographic criteria (gender, handedness, etc.), who or what decided that those individual were depressed? Were they depressed for a long time or only recently? Were they actively depressed while they were being scanned? Had they ever taken antidepressant medication? Regarding the image shown, how many of the individuals had brain images that looked like it, and what was the variation in images of depressed people?

Turning from the individual images, we also notice how *together* they argue that there are three different kinds of brains that correspond to the three kinds of brain images. Because the images are so clearly different from each other, they make the additional argument that each brain kind is easily distinguishable, and thus they promise that a PET scan can make a diagnosis—of schizophrenia, depression, and normality, in this case. If we pay close attention to the shape of the images and know that PET images are pictures of "slices" of brains, then we notice that the three images appear to be different slices of the brains, or at least that the three brains are very different in shape and size. In this case we might *expect* that they would, of course, look different. However, we would wonder whether, if we took the same slice in each "kind" of brain, the PET images would look so different. Perhaps each slice has been chosen to emphasize the part of the brain implicated in the condition. How could we tell this? And what slice would be implicated in a "normal brain," then?[6]

All of this is to say that what we come to receive as facts about ourselves are analyzable from a number of perspectives. We might look at the cultural salience of categories like mental illness and gender. We might look at the fundability of different approaches to brain scanning. We might attend to the available metaphors for thinking about brains and people. Though this may seem critical of the science, these perspectives are the same ones from which scientists talk and debate about their work and its dissemination. Scientists continually have to deal with not only the recalcitrance of their instruments and the resistance of the world but also disciplinary constraints, funders and patrons, competitive colleagues, students in training, social mores and values, and lay interpretations.[7] Everyday notions of human kinds help shape what sorts of questions scientists are allowed to ask and what sorts of selection procedures they enact on their subjects. Idioms and metaphors (e.g., flexibility, efficiency, circuitry, and inhibition) are produced in part by cultural uses and travel back into laboratories. It is out of this busy intersection of technical, social, and cultural flows that scientists attempt to stabilize and conduct their experiments, and it is back into the intersection that their results must go.[8]

These flows enable and constrain science at every level of fact conception, experimentation, publication, and dissemination, and reception, but this does not imply that science *is* culture. There is an interplay between popularization processes and scientific inquiry. Science produces facts in spite of and because of these constraints—laboriously, continuously, and creatively. And we fashion our objective-selves with the fruit of this labor in the form of received-facts in our own continuous and often creative manner, no matter how skeptical we are. This way of living with and through scientific facts is our form of life.[9]

In this book, we will investigate brain images as they are presented in a variety of settings, in order to become better-informed science readers and, some of us, better scientists. Much of the disciplines of the history of science and science and technology studies (STS) concentrate on teasing out the difficulties of establishing facts in a particular place and time.[10] These scholars show how creatively and laboriously science is put together. Thus, we will need to investigate the production of images, including specific machines and experiments, in order to understand how, why, and when assumptions are made. We need to understand that there are different kinds of assumptions: (1) necessary assumptions in the absence of settled answers; (2) efficient assumptions in the face of practical and economic constraints; and (3) provisional assumptions because the experiment itself is hypothesis-generating. Using cultural anthropology, in addition to examining how brain images are painstakingly put together, we will also study how they travel from one setting (e.g., a lab) to another (e.g., a magazine) and what meanings they both lose and pick up in the process. Thus we will learn to pay attention to received facts and to how brain images are put to persuasive use in specific contexts.

The lack of ultimate clarifications as to what brain images mean—in abstract or in a particular use—is a consequence of our considering them in use (and potential reuse and thus reinterpretation). Objective-selves, received-facts, and brain-types are thus "*not terms that avoid ambiguity*, but *terms that clearly reveal the strategic spots at which ambiguities necessarily arise*" (Burke 1945, p. xix; emphasis in original). Following Kenneth Burke,

> Instead of considering it our task to dispose of any ambiguity by merely disclosing the fact that it is an ambiguity, we rather consider it our task to study and clarify the *resources* of ambiguity. . . . For in the course of our work, we shall deal with many kinds of transformation—and it is in the areas of ambiguity that transformations take place. (Burke 1945, p. xviii; emphasis in original)

Methods: An Ethnography of Images

How should or can neuroscientists be accountable for their speculations as they travel into print and into courtrooms? How can we account for these speculations, and are these speculations in fact grounded in a shared cultural notion of personhood and human difference? How do we, can we, might we respond to these conclusions regarding ourselves?

Questions of how brain images function in the world and how we are accountable to them have no simple answer. Investigating them requires a combination of cultural anthropology, STS cultural studies, and history. This project began as an interdisciplinary investigation into the process of producing, disseminating, and incorporating PET experiments into our lives. My model was Appadurai and Kopytoff's ethnographic approach to the "social life of things" (Appadurai 1986; Kopytoff 1986). Meaning, from a cultural anthropological perspective, is a lived relation among cultural actors, and to the extent that things such as images and technologies are attributed agency, they, too, participate in cultural exchange. My intention was to trace the various ways in which experiments were designed with assumed categories of people, how they were carried out and interpreted, published in technical and popular literature, and read and incorporated into further experiments, patients' lives, and everyday notions of personhood. Focusing on the images, I set out to study how these scans were desired, laboriously generated, selected, captioned, published, read, interpreted, argued over, referred to, and forgotten.

My primary mode of fieldwork was to "follow" the images around. I started with both images in the media and with image producers. I conducted extensive oral histories with key PET researchers at six different PET labs in the United States. I interviewed many others, including graduate students and postdoctoral scholars, watched experiments being conducted, and observed day-to-day practices. I studied the practices of writing research grants, attended conferences and public lectures, interviewed science editors and other mass-media producers, looked at the use of brain images in courtrooms, and talked to patients and patient-activists about their experiences with scans.[11]

Difficulties with this approach arose immediately. As a complex, multidisciplinary enterprise, PET has multiple, competing identities. PET also has no unitary history, nor even a definition to which a majority agree. In a single article for *Newsweek*, for example, each PET image included was disavowed by other researchers appearing in the same article, as not very meaningful. In addition, PET's controversial use in courtrooms, contested clinical status, and diverse potential in mental-illness communities made it a very fluid object of study. The challenge became to account both for the multiplicity of PET's meanings and practices and for the powerful circulation of the images into different social arenas.

The "field" of an ethnographic study of images must include, then, not only their "biographies" but also what can be called their "virtual community" By using the term *virtual community*, I am borrowing Allecquere Stone's notion of communities that include technologies as vital participants. These communities are dispersed in space, and although each participant is not necessarily connected directly to every other one, they all interact indirectly with each other via technologies of communication (Stone 1992). There are popular theories of person and science that are also the basis of science theorizing. In terms of PET, all those who meaningfully interact with PET images are part of the virtual community. There are laboratories and granting agencies; there are journals and publishing apparatuses; there are machines, brains and people. Finally, there are definitions and demarcations of authority that interweave all of these—science versus (popular) culture, technology versus society, normal versus not normal—demarcations that are shorthand for the ways in which attributions of agencies, functions, and types are

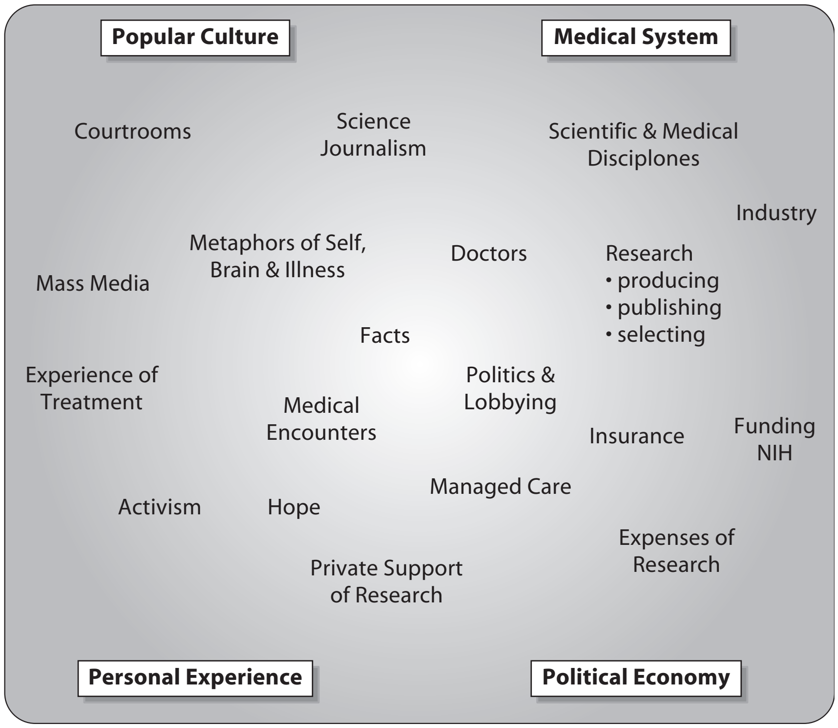

FIGURE 1.2. Virtual community diagram. Heuristic diagram of the "virtual community" of PET brain images. Actors are distributed roughly into four quadrants. The point of this diagram is not to reify the various actors, but to help us keep in mind the wide range of them and their interactions.

distributed, disputed, and constrained. In particular, I am working to locate contests over the true nature of human nature, sites where metaphors are incomplete or excessive and where they are changing. I am interested in the mechanisms of these shifts, their uneven spread, the coexistence of opposing discourses, local existences, and conflicts that involve PET scans.

Because I am interested in the introduction of new facts about biological bodies and brains, I needed to find a way to talk about how the culturally constituted bodily experiences might change (Grosz 1994). In chapter 4 ("Ways of Seeing Brains as Expert Images"), I argue that PET scans are far better suited to show differences and abnormalities than they are to show that someone is normal or that there are no significant differences between groups, and that this inherent preference has powerful consequences when these scans are used in courtrooms. In chapter 5 ("Traveling Images, Popularizing Brains"), I use the concept of objective-self fashioning to look at how facts from science are experienced as objective. In each case, I argue that the consequences of these practices and contests over meaning do, in fact, matter to us. They make important differences in the world.

I also know that these contests are not simply about expert scientists trying to reach consensus over technical issues. Instead, these contests are socially embedded across spheres of activity: mass-media science journalism, mental-illness activism, courtroom admissibility, and widespread readership of published speculations, as well as neuroscientific research. Each of these spheres has its own histories and political economies of the evaluation and dissemination of scientific information. Each of these spheres also has different kinds of stakes in the reproduction of information about the biological makeup of humans.[12]

As an interdisciplinary ethnographer, my interest is in discovering how these different stakes relate to each other, and how these different spheres are connected with and interdependent on each other. My aim is to help evoke these interdependencies and intervene in the ongoing contests over meaning. My position within the virtual community of PET scans is as an anthropologist and historian.[13] I want to evoke the effective and affective *power* that these images, as visual facts, come to have in different arenas of social life, hospitals, mental-illness communities, courtrooms, scientific meetings, laboratories, and in the mass media. And I want to provoke discussion regarding this power. I have been using this position to locate struggles over meaning and power that cross boundaries of expertise and that seem to involve questions of multiple accountability between groups (who do not, themselves, explicitly acknowledge such accountability). Given that the process and outcome of these struggles matters to me personally (as an informed layperson within the virtual community of these scans), one aim of this book is to participate in, and in some cases create, conversations that explain for these multiple accountabilities (Downey and Dumit 1997b).

By respecting both the critical significance of the scientific, technical, and medical expertise and the the implication of public cultural categories in spheres outside of these defined areas of expertise, this book strives to make clear some of the stakes shared—or at least contested—by all participants in PET. Second, I hope to foreground specific current directions of interdisciplinary and intersocial negotiations over the meaning and status of PET images in popular media, mental-illness communities, and courtrooms, in order to raise questions of how these practices might become social problems and begin a discussion on how they might be otherwise.

This work is perhaps best seen as a kind of window into the movements of PET scans in the world: part cultural studies and philosophy (What are PET scans, and how do they function in the world?), part history (How did they arise in these ways?), and part anthropology (How are they meaningful to different communities of people?). As such, it lays the groundwork for more specific cultural projects in the future. In the conclusion, I lay out one such project, looking at the PET functional brain studies of emotions—in particular, sadness and depression.

Two key issues in all big science are money and credit. Grants and publications are the oxygen and glucose, respectively, of research life. They are, of course, both administered through peer review. Alternate forms of funding are both less prestigious and controversial. On the one hand, the PET community is small enough that it is impossible for me to relate specific histories of funding and publication without entering into the local controversies and violating anonymity requests. On the other hand, to tell these histories without the controversies is potentially to perpetuate and/or exacerbate these problems.[14]

Throughout this book are excerpts from interviews I have conducted with PET researchers, from lab leaders to graduate students. Most of these are transcribed quotations from taped interviews that have been edited by both the speaker and myself for readability and accuracy. Others are fieldnotes recorded by me after conversations. In many cases, I do not identify the speaker and have edited out identifying remarks. I have chosen this anonymity to protect those who wished not to be quoted directly and also to evoke a range of positions within the PET community on different issues.

Each of these chapters juxtaposes interview material, semiotic analyses, ethnographic observations, and theoretical reflection. They are written to intervene by engaging. Their tone is exploratory. Like PET neuroscience studies, they are hypothesis-generating, not hypothesis-confirming. Interspersed between most chapters are interludes—conversations between myself and researchers highlighting both the nature of my questioning and the richness of their answers. In general, I prefer long quotations to shorter ones. Long quotations preserve much more of the multiple stakes that researchers constantly negotiate, as well as their explicit awareness of the philosophical, epistemological, and practical aspects of their work.[15]

How This Book Is Organized

CHAPTER 2: METAPHORS, HISTORIES, AND VISIONS OF PET

Chapter 2 provides an overview of the many definitions of PET scanning and, consequently, the many different histories of PET that can be told. On the basis of interviews with three key researchers, PET is variously defined as a pathbreaking technological invention, as a significant direction of research, and as one among many neuroscience tools. Each of these stories of PET conceptualizes the brain in different ways and therefore the kinds of experiments that PET is suited for. With these different basic conceptual notes of what can be studied with PET come different notions of normality, of functions in the brain, and of objective-selves. Each story is also a history and embodies different notions of good science and of scientific progress, as well as the relative centrality of personal contributions. The purpose of chapter 2 is to juxtapose different perspectives while accounting for *how* these views are opposed, in order that a more objective account might be achieved.

CHAPTER 3: PRODUCING BRAIN IMAGES OF MIND

Brain images are produced for a variety of reasons, often contradictory. As with all natural human science, they contain assumptions from a whole apparatus but appear simple and represent types because of the imaging process. In most cases, PET brain-type research is triangulating between (1) groups of subjects selected according to often accurate but imprecise behavioral criteria; (2) the small sampling of the selected populations under study, usually between 4 and 20 people per group; and (3) a "functional" (flow rate) anatomy of the brain that is also imprecise and to some extent unknown at the millimeter level. The resulting PET images, generated at the intersection of these three imprecise referents, are thus paradoxically the most concrete, analytical data available as to whether a behavioral criterion (e.g., a schizophrenia diagnosis) or task (e.g., remembering a number) is reliably handled differently than by the brains of other subjects (e.g., normals) or by the same subjects doing a different task (e.g., resting quietly). The miracle is that we are able to safely and repeatedly get any precise locational data at all about brain functions in living subjects. Historically, no other technique except PET and similar tomographic imagers (functional magnetic resonance imaging [fMRI] and single-photon emission computed tomography [SPECT]) has given quantitative locational information about brain function.

Brain-imaging technologies like PET offer researchers the potential to ask a question about almost any aspect of human nature, human behavior, or human kinds and design an experiment to look for the answer in the brain. Each piece of experimental design, data generation, and data analysis, however, necessarily builds in assumptions about human nature, about how the brain works, and how person and brain are related. No researcher denies this. In fact, they constantly discuss assumptions as obstacles to be overcome and as trade-offs between specificity and generalization. The aim of this chapter is to systematically outline how and where these assumptions are built in so they can be tracked as the images travel.

Properly representing results of these experiments is another balancing act. This time the balance is between the many kinds of audiences who will encounter these complex images: fellow brain-imaging researchers, other neuroscientists, science journalists, and the public. For those publishing brain images, the question is often how to balance the persuasiveness of the visual scans of *simple difference* with the desire for those images to also represent the significance of the experimental data.

This practice of actively constructing images for publication is neither surprising nor new. Similar issues have been observed concerning graphs, tables, digital astronomical images, and physics' images (Jones et al. 1998; Lynch 1993; Lynch and Woolgar 1990). Images are produced and selected for publication to make particular points and to illustrate the argument and other data presented, not to stand alone. They are, in other words, explicitly rhetorical. This is, one could say, the only way one can present images.

Researchers in the same field know this and read each others' images very critically. They go right to the data, methods, qualifications, and statistical results, and they adjust these depending on genre and audience: granting agencies, journals, interdisciplinary forums, and the general public. Observing this practice, I am concerned with the ways in which brain images and their interpretations as referring to brain-types are appropriated and transformed for further use at each stage of image production, selection, and dissemination, scientifically and popularly. Among scientists, this includes looking at how they design their machines and experiments, how they appropriate each other's work across disciplinary lines, and how they cooperate and compete. With each appropriation and subsequent translation, the content of the image, its qualifications and brain-type referent, changes.

CHAPTER 4: WAYS OF SEEING BRAINS AS EXPERT IMAGES

This chapter looks at how American courts have appropriated brain images as useful evidence by incorporating them into the legal category of demonstrative illustration. Surveying the history of the court's use of images, from photographs to X-rays to computed tomography (CT) and PET, we can begin to understand how none of these images were immediately persuasive or understandable. Each kind of image required a "learning to see," by scientists and doctors as well as laypersons.

The persuasiveness and truth status of these learned images before juries is an ongoing concern of the court. Digital brain images are often presented as automatic, computed, and objective illustrations demonstrating insanity and incompetency. PET images thus seem to have a persuasive power that is out of proportion to the data they are presenting. The scans become visual truths, presenting themselves as facts about people and the world such that even their own producers cannot refute them. My suggestion is that the courtroom use of PET images, which most researchers dislike so much, is actually enabled by the way the images are presented by them in journals. Intrascientific communication, in other words, is not a closed world at all but a participant in contests over human nature, rationality, and cause and effect with the rest of society.

We will pay particular attention to how images are recaptioned, decontextualized, and recontextualized, and how they are presented in relation to other images. We do not have to suspect the accuracy of the underlying experiments to recognize that the visual appearance of "graphically" different brain-type images is produced, in part, by a *choice* to visualize the data as *very* different in color. Comparative images are one of the most powerful, persuasive presentations of brain-type data. If nothing else, they visually convey clear-cut graphical difference that *can* be easily *read* in some situations as referring to clear-cut statistical difference or even absolute difference in populations and brain-types. Thus, they *can* help produce, in some situations, the identification of groups as brain-types.

We must emphasize the word *can*, and the form and location of these readings, because we need to be constantly wary of easy assignments of blame for (mis)readings. Scientists take great pains to qualify the meaning of their images (e.g., schizophrenic and normal) and make sure that the conclusions they present do not overstep their data. In this, they are appropriate with the culturally accepted norms of their disciplines. Many of these scientists clearly state in their articles that there is no way, yet, to go from scan to diagnosis, that the correlation is nowhere near being established. Yet most of these same scientists explicitly hate the fact that PET images of schizophrenics can be shown to help persuade juries that a person has schizophrenia. This chapter thus investigates how the visual practices of PET researchers—how they produce, choose, and publish images—enables many of these appropriations that the researchers so abhor.

CHAPTER 5: TRAVELING IMAGES, POPULARIZING BRAINS

Chapter 5 builds on all of the preceding chapters to enter into another set of contested meanings involving PET scans. Defining and treating mental illness has a long and troubled history of conflicts, accusations, and accountabilities between biologists, psychotherapists, neurologists, psychiatrists, criminologists, mothers, fathers, families, genes, drugs, communities, and patients. PET scans weigh into these contests as visual evidence of brain differences between those with mental illness and those without it. PET often enters as proof of the biological existence of mental illness in the brain. Chapter 5 follows some of the ways in which this evidence is generated, presented, debated, and incorporated into people's lives. Attending to many issues involved in the political economy of PET research as well as mental-illness diagnosis and treatment, it raises issues regarding concurrent positive and negative effects of PET demonstrations today. In the case of mentally ill patients and their families, the ability of PET to show biological differences promises an understanding of biological origins and the promise of a cure in the long term. In the short term, this "proof" of biological origin both empowers some families to face mental illness as a disease and not a failure of will and has potentially disempowering effects for those who depend on community-based mental-health institutions. Blame and accountability are not easily assigned. But an ethnographic approach to the virtual community of PET scans has the potential to bring different perspectives into conversation, and it can highlight some of the unintended effects of cultural equations and scientific practices.

CHAPTER 6: CONCLUSION

In effect, each of these chapters is a slice through the virtual community of PET scans. Each brings some members of the community into relation with each other and ignores others. Collectively, these chapters aim to evoke the busy intersection between culture in its popular, forensic, and activist manifestations, and neuroscience; to watch its traffic and borrowings; and to draw some lines of accountability between what appears to be gulfs, ultimately, of expertise, of knowledge, and of consequences.[16] I am interested in PET because it is not over—it is still being defined; its purpose is still under debate—because it is part of the rewriting of our received-facts about ourselves as biological, sentient beings.

Interlude 1
Thinking about Reading

Intrigued with brains and the meaning of machines that might be able to record thought processes in the brain (figure 1.3; see Plate 14). Philosopher Ludwig Wittgenstein, in 1936, considered the problem of whether and how we can objectively tell when someone is truly reading. He surmised that perhaps there is no way to tell:

> But isn't that only because of our too slight acquaintance with what goes on in the brain and the nervous system? If we had a more accurate knowledge of these things we should see what connexions were established by the training, and then we should be able to say when we looked into his brain: "Now he has read this word, now the reading connexion has been set up."—And it presumably must be like that—for otherwise how could we be so sure that there was such a connexion? That it is so is presumably a priori—or is it only probable? And how probable is it? Now ask yourself: what do you know about these things?—But if it is *a priori*, that means that it is a form of account which is very convincing to us. (Wittgenstein 1986, §158)

Wittgenstein's exploration of the boundaries of the meaning of *a priori* brings him to culture: We know these things because we have read them in textbooks and heard them from adults whom we trust. "How do we know," he was fond of asking, "that we have a brain, if we have never seen it?"[17] We have, he suggested, a kind of certainty that seems a priori, intuitively self-evident: "Of course, it must be like that." This kind of certainty would be learned (because we are not born knowing about our brains), and yet logical. In order to further explore the limits

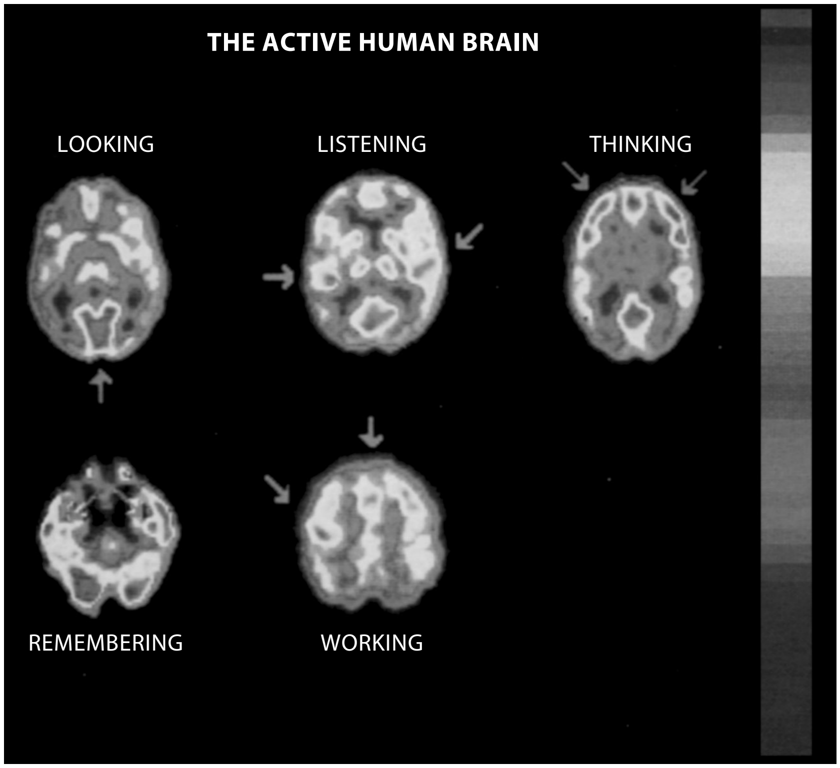

FIGURE 1.3. Active human brain. PET studies from the UCLA School of Medicine showing changes in glucose metabolic function of the brain when healthy volunteers are asked to perform different tasks. (Michael E. Phelps 1991)

of our certainty, consider a variation on Wittgenstein's thought experiment. What if a research team published an article demonstrating that a specific, reliable change in the blood flow of the big toe was correlated with a person's learning to read? This would be greeted skeptically at best, and if it were repeated in person after person, we would not say, "Okay, reading *is* a function of the toe." Instead, we would ask, "Well, what *causes* the blood flow in the toe?" And if we eventually located a correspondence between an area of the brain and the big toe, even if the brain "signal" were weaker and less reliable than the toe "signal," this would then nevertheless confirm to us that reading was in the brain and that the toe flow was a "symptom" of the brain process. But why is it that when we find a reading correspondence in the brain we are satisfied that we are in the right place? Because, suggested Wittgenstein, that is our form of life, our local culture. At certain points (and not others), we no longer ask for an explanation or a test of its truth; explanations come to an end.

> Giving grounds, however, justifying the evidence, comes to an end;— but the end is not certain propositions' striking us immediately as true, i.e., it is not a kind of seeing on our part; it is our *acting*, which lies at the bottom of the language game.[18] (Wittgenstein 1991, §204)