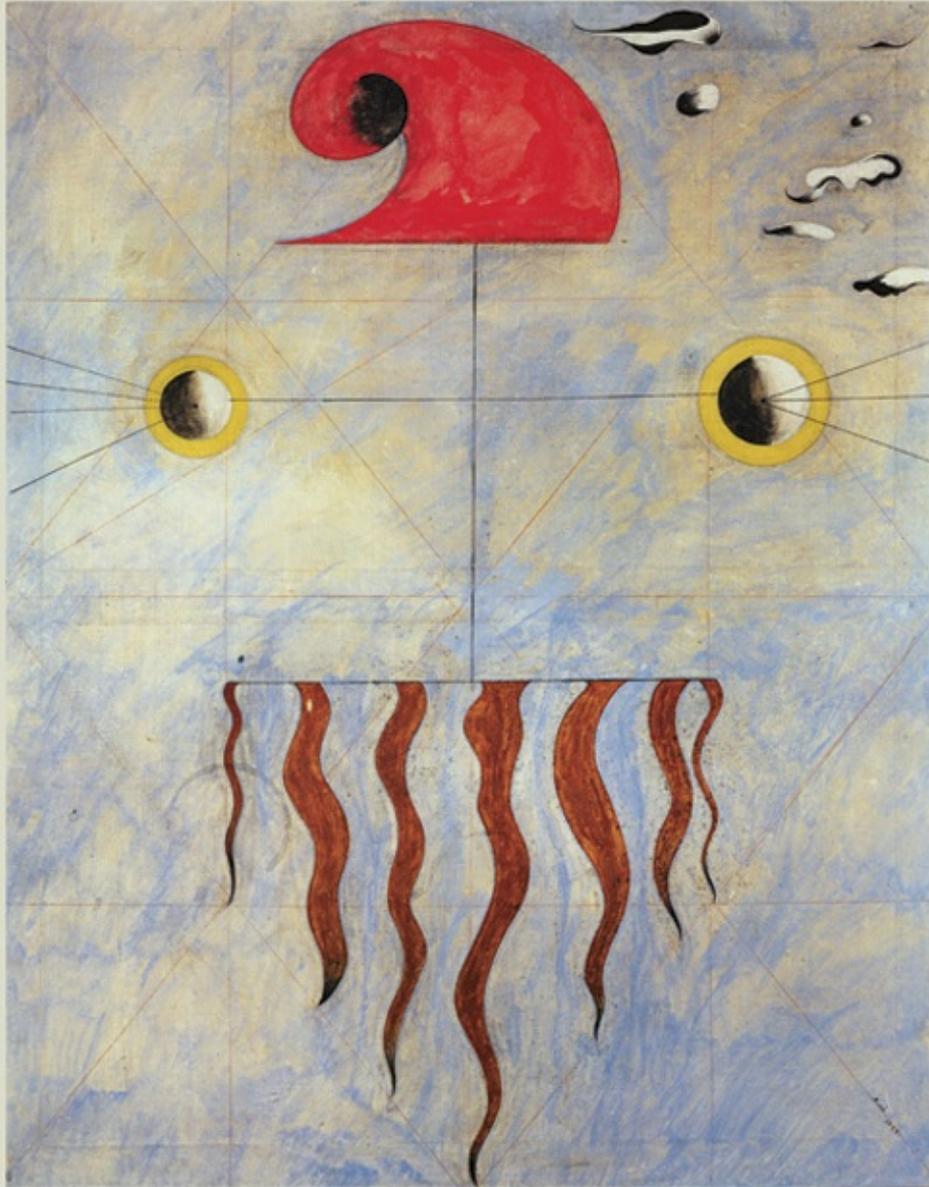


Neuro

The New Brain Sciences and
the Management of the Mind



Nikolas Rose and Joelle M. Abi-Rached

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For Diana, as always.
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For my parents, May and Maroun.
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Abbreviations

AD:	Alzheimer's disease
ADHD:	attention deficit hyperactivity disorder
APA:	American Psychiatric Association
APIRE:	American Psychiatric Institute for Research and Education
BNA:	British Neuroscience Association
BOLD:	blood-oxygen-level-dependent (contrast imaging)
BPD:	bipolar disorder (sometimes termed "manic depression")
BRA:	Brain Research Association
Caltech:	California Intitute of Technology
CNRS:	Centre National de la Recherche Scientifique (France)
CNVs:	copy number variations
CT scan:	Computerized tomography (formerly computerized axial tomography or CAT scan)
DALYs:	disability adjusted life years
<i>DSM:</i>	<i>Diagnostic and Statistical Manual of Mental Disorders</i>
DSPD:	dangerous and severe personality disorder
EBC:	European Brain Council
ECNP:	European College of Neuropsychopharmacology
EEG:	electroencephalography
ENSN:	European Neuroscience and Society Network
ESF:	European Science Foundation
ESRC:	Economic and Social Research Council (U.K.)
FDA:	Food and Drug Administration (U.S.)
fMRI:	functional magnetic resonance imaging
GWAS:	genome-wide association studies
IBRO:	International Brain Research Organization
ICD:	International Classification of Diseases
LSD:	lysergic acid diethylamide
MAOA:	monoamine oxidase A
MCI:	mild cognitive impairment

MIT:	Massachusetts Institute of Technology
MRC:	Medical Research Council (U.K.)
MRI:	magnetic resonance imaging
NESARC:	National Epidemiologic Survey on Alcohol and Related Conditions (U.S.)
NGBRI:	not guilty by reason of insanity
NHS:	National Health Service (U.K.)
NIDA:	National Institute on Drug Abuse (U.S.)
NIH:	National Institutes of Health (U.S.)
NIMH:	National Institute of Mental Health (U.S.)
NMR:	nuclear magnetic resonance
NRP:	Neurosciences Research Program (U.S.)
<i>OED:</i>	<i>Oxford English Dictionary</i>
PET:	positron emission tomography
RSA:	Royal Society for the Encouragement of Arts, Manufactures and Commerce (U.K.)
SfN:	Society for Neuroscience
SNPs:	single nucleotide polymorphisms (pronounced “snips”)
SPECT:	single photon emission computed tomography
SSRI:	selective serotonin receptor inhibitor
UC Berkeley:	University of California, Berkeley
UCLA:	University of California, Los Angeles
WHO:	World Health Organization
YLDs:	years lived with disability

Introduction

What kind of beings do we think we are? This may seem a philosophical question. In part it is, but it is far from abstract. It is at the core of the philosophies we live by. It goes to the heart of how we bring up our children, run our schools, organize our social policies, manage our economic affairs, treat those who commit crimes or whom we deem mentally ill, and perhaps even how we value beauty in art and life. It bears on the ways we understand our own feelings and desires, narrate our biographies, think about our futures, and formulate our ethics. Are we spiritual creatures, inhabited by an immaterial soul? Are we driven by instincts and passions that must be trained and civilized by discipline and the inculcation of habits? Are we unique among the animals, blessed or cursed with minds, language, consciousness, and conscience? Are we psychological persons, inhabited by a deep, interior psyche that is shaped by experience, symbols and signs, meaning and culture? Is our very nature as human beings shaped by the structure and functions of our brains?

Over the past half century, some have come to believe that the last of these answers is the truest—that our brains hold the key to whom we are. They suggest that developments in the sciences of the brain are, at last, beginning to map the processes that make our humanity possible—as individuals, as societies, and as a species. These references to the brain do not efface all the other answers that contemporary culture gives to the question of who we are. But it seems that these other ways of thinking of ourselves—of our psychological lives, our habitual activities, our social relations, our ethical values and commitments, our perceptions of others—are being reshaped. They must now be grounded in one organ of our bodies—the spongy mass of the human brain, encapsulated by the skull, which weighs about three pounds in an adult and makes up about 2% of his or her body weight. This ‘materialist’ belief has taken a very material form. There has been a rapid growth in investment of money and human effort in neurobiological research, a remarkable increase in the numbers of papers published in neuroscience journals, a spate of books about the brain for lay readers, and many well-publicized claims that key aspects of human affairs can and should be governed in the light of neuroscientific knowledge. A host of neurotechnologies have been invented—drugs, devices, techniques—that seem to open ourselves up to new strategies of intervention through the brain. In the societies of what we used to call the West, our brains are becoming central to understanding who we are as human beings.¹

For many in the social and human sciences, these developments are profoundly threatening. Their unspoken premise, for at least the past century, has been that human beings are *freed* from their biology *by virtue of that biology*—that we come into the world unfinished and that our individual capacities, mores, values, thoughts, desires, emotions (in short, our mental lives), as well as our group identities, family structures, loyalties to others, and so forth are shaped by upbringing, culture, society, and history. Practitioners of these disciplines can point, with good reason, to the disastrous sociopolitical consequences of the biologization of human beings: from eighteenth-century racial science to twentieth-century eugenics, and more recently to the reductionist simplifications of sociobiology and evolutionary psychology. To give priority to the biological in human affairs, it seems, is not

only to ignore what we have learned from more than two centuries of social, historical, and cultural research, but also to cede many of the hard-won disciplinary and institutional achievements of the social and human sciences to others, and to risk their sociopolitical credibility.

We are sympathetic to these anxieties, and there is much truth in them. One only has to glance at the wild overstatements made by many of the popular writers in this field, the recurring overinterpretation of the findings from animal research in neurobiology, the sometimes willful misrepresentation of the significance of the images generated by brain scanning, not to mention the marketing on the Internet of many dubious products for improving brain power, to realize that there is much scope for critical sociological analysis and for cultural investigation of the contemporary lure of the brain sciences. But in this book, while we certainly seek to develop tools for a critical relation to many of the claims made in both serious and popular presentations of neuroscience, we also seek to trace out some directions for a more affirmative relation to the new sciences of brain and mind.

We do this for two reasons. On the one hand, there is no reason for those from the social and human sciences to fear reference to the role of the human brain in human affairs, or to regard these new images of the human being, these new ontologies, as fundamentally threatening. These disciplines have managed to live happily with the claims of psychoanalysis and dynamic psychologies, even though these disciplines also see much of human individual mental life and conduct as grounded in processes unavailable to our consciousness. Perhaps then, we should not be so wary of the reminder that we humans are, after all, animals—very remarkable ones, indeed, but nonetheless not the beneficiaries of some special creation that sets us in principle apart from our forebears.² And, on the other hand, the new brain sciences share much with more general shifts within contemporary biological and biomedical science: at their most sophisticated, they are struggling toward a way of thinking in which organic corporeality is in constant transaction with its milieu, and the biological and the social are not distinct but intertwined. Many of the assumptions and extrapolations that are built into the heterogeneous endeavor of neurobiology are ripe for critique. But at a time when neurobiology, however hesitantly, is opening its explanatory systems to arguments and evidence from the social sciences, perhaps there is a relation beyond commentary and critique that might be more productive. We will return to these issues in our conclusion. For now, though, it is sufficient to say that it is in the spirit of critical friendship between the human sciences and the neurosciences that we have written this book.

Beyond Cartesianism?

Mind is what brain does. This little phrase seems to encapsulate the premise of contemporary neurobiology. For many, it now merely states the obvious. But it was not always so. In 1950 the BBC broadcast a series of talks titled *The Physical Basis of Mind*, introduced by the eminent neurophysiologist Sir Charles Sherrington, with contributions from leading philosophers, psychiatrists, and neurologists (Laslett 1950). In his opening remarks, Sherrington pointed out that half a century earlier he had written, “We have to regard the relation of mind to brain as still not merely unsolved, but still devoid of a basis for its very beginning”; in 1950, at the age of ninety-two, he saw no reason to change his view: “Aristotle, two thousand years ago

was asking how the mind is attached to the body. We are asking that question still. Whatever their differences, all the distinguished contributors to this series agreed that the debate over the relation between mind and body, between mind and brain, had lasted many centuries, and that it was unlikely that a consensus would soon be reached as to whether there *was* a physical basis for the mind in the brain, let alone what that basis was, or where it was, or how such a basis should be conceptualized.⁴

A half century later, Vernon Mountcastle, celebrated for his fundamental discoveries about the structure of the cerebral cortex, contributed the introductory essay on “Brain Science in the Century’s Ebb” to a special issue of *Daedalus* (the journal of the American Academy of Arts and Sciences) devoted to the state of brain research. “The half-century’s accumulation of knowledge of brain function,” he wrote, “has brought us face to face with the question of what it means to be human. We make no pretention that solutions are at hand, but assert that what makes man human is his brain.... Things mental, indeed minds, are emergent properties of brains” (Mountcastle 1998, 1).⁵ Minds are properties of that organ of the body that we term the brain. And brains makes humans human, because the minds that constitute the humanity emerge from their brains. Mountcastle spoke here for most of those working in the field that had come to call itself neuroscience. In a way that they did not quite understand and yet that they could not doubt, the human mind did indeed have a physical basis in the human brain. And that brain, however remarkable and complex, was an organ like any other organ, in principle open to neuroscientific knowledge: the ‘explanatory gap’ between the processes of brain and the processes of mind they somehow produce was beginning to narrow and would, in time, be closed.

Of course, many would say, there is nothing much new here. Have we not known that the brain is the seat of consciousness, will, emotion, and cognition since the Greeks? Closer to our present, from the nineteenth century onward, especially in Europe and North America, there was an intense focus on the significance of the brain to human character, to human mental pathologies, and to the management of the moral order of society: while many may now scoff at the attempts of the phrenologists to read intellectual and moral dispositions from the shape and contours of the skull, few would dispute the pioneering work on brain anatomy and function memorialized in the brain areas designated by the names of Wernicke, Broca, Flechsig, and their colleagues (Hagner 1997, 2001; Hagner and Borck 2001). If we wanted further evidence that there was nothing new about the salience long accorded to brain research, we could point to the fact that in the first six decades of the twentieth century more than twenty scientists were honored by the award of a Nobel prize for discoveries concerning the nervous system—from Santiago Ramon y Cajal in 1906 to John Eccles, Alan Hodgkin, and Andrew Huxley in 1963.

Nor is there anything particularly novel in the challenge that contemporary neuroscientists mount to dualism. For example, in the early decades of the twentieth century, Charles Sherrington sought to develop an integrated theory of brain and mind, and this was the prelude to a host of neurological, psychological, and philosophical attempts to clarify the mind-body relation; it also led to a host of worries about the implications for the highest human values of morality, autonomy, wholeness, and individuality (R. Smith 2002). Like their contemporaries today, neurologists and brain researchers in the first half of the twentieth century certainly believed—and claimed—that their research had uncovered

mechanisms of the brain that would have major social implications. The gradual acceptance of the usefulness of the electroencephalograph in the 1930s, and the image of the electric brain that it seemed to embody, appeared to some (notably William Grey Walter) to offer the possibility of objective diagnoses of psychiatric conditions, and indeed of normal characteristics; it was thought of “as a kind of truth machine or electrical confessional” that would reveal the workings of the human mind and enable public access to private mental life and also have implications for the management of everything from child rearing to the choice of marriage partners (R. Hayward 2002, 620–21ff.). Perhaps, then, when neuroscientist Michael Gazzaniga titled his recent book *Human: The Science behind What Makes Us Unique* (Gazzaniga 2008a), claiming that advances in research on the brain will reshape our understandings of who we are, he was only the latest in a long tradition.

Yet, as the twenty-first century began, there was a pervasive sense, among the neuroscientific researchers themselves, among clinicians, commentators, writers of popular science books, and policymakers that advances in our understanding of the human brain had implications that were nothing short of revolutionary. Much had indeed changed in the fifty years between Sherrington’s pessimism and Mountcastle’s optimism. By the end of the twentieth century, the term *neuroscience* slipped easily off the tongue, yet it dates only to 1962.⁶ The Society for Neuroscience (SfN) was formed in 1969 and held its first major conference in 1979, which was attended by about 1,300 people; by 1980 it attracted about 5,800 people; by 1990 this number had grown to more than 13,000; and by 2000 it reached more than 24,000.⁷ Alongside this annual event there were now dozens of other conferences and workshops organized by more specialist associations of brain researchers, each with its own membership, websites, and newsletters, along with undergraduate and graduate programs in neuroscience, ‘boot camps’ for those who sought a rapid immersion in the field, and much more. These activities were not confined to the United States but spanned Europe, Japan, China, and many other countries. This was not a unified field: there were many different formulations of the problems, concepts, experimental practices, professional allegiances, and so forth. But nonetheless, by the start of the twenty-first century, a truly global infrastructure for neuroscience research had taken shape.

These organizational changes were accompanied by a remarkable burgeoning of research and publishing. While in 1958 there were only some 650 papers published in the brain sciences, by 1978 there were more than 6,500. By 1998 this figure had risen to more than 17,000, and in 2008 alone more than 26,500 refereed papers were published on the neurosciences in more than four hundred journals.⁸ In the wake of the decade of the 1990s, which U.S. President George Bush designated “the decade of the brain,” things seemed to shift into a new phase, with discussions of the crucial role of the brain for individuals and societies in the light of advances in neuroscience moving from the specialized literature into a wider domain. In the subsequent ten years, dozens of books were published suggesting that we have witnessed the birth of new sciences of brain and/or mind, and drawing on research findings to illustrate these claims (Andreasen 2001; Kandel 2006; Restak 2006; Iacoboni 2008; Rizzolatti and Sinigaglia 2008; Begley 2009; Lynch and Laursen 2009).⁹ These books, and the regular newspaper articles and television programs about these discoveries and their importance, are now almost always accompanied by vibrant visual illustrations derived from brain imaging of the living brain in action as it thinks, feels, decides, and desires (Beaulieu

2002): the brain has entered popular culture, and mind seems visible in the brain itself.

Governing through the Brain

By the turn of the century, it seemed difficult to deny that the neurosciences had, or should have, something to say about the ways we should understand, manage, and treat human beings—for practices of cure, reform, and individual and social improvement. Across the first half of the twentieth century, the prefix *psy-* was attached to a great many fields of investigation of human behavior, seeming to link expertise and authority to a body of objective knowledge about human beings (Rose 1989); now the prefix *neuro-* was being invoked in the same way. Psychiatry was an obvious niche, not least because of the belief since the 1950s, that new pharmacological treatments had been discovered that were effective because they acted directly on the neurobiology underpinning mental disorder. While the term *neuropsychiatry* had been used as early as the 1920s (for example, Schallert 1922) and gained popularity in the European literature in the 1950s (for example, Davison 1950; Garrard 1950; Hecaen 1950), by the start of the twenty-first century the term was being used in a very specific sense—to argue that the future of psychiatry lay in the integration of insights from genetics and neurobiology into clinical practice (Healy 1997; Martin 2002; Sachdev 2002, 2005; Yudofsky and Hales 2002; Lee, Ng, and Lee 2008).

But while psychiatry might seem an obvious niche for neuroscience, it was not alone in using the *neuro-*prefix to designate a novel explanatory framework for investigating phenomena previously understood in social, psychological, philosophical, or even spiritual terms.¹⁰ Thus we now find *neurolaw*, which, especially in its U.S. version, claims that neuroscientific discoveries will have profound consequences for the legal system, from witness interrogation to ideas about free will and programs of reform and prevention; the first papers proposing this term appeared in the mid-1990s (Taylor, Harp, and Elliott 1995; Taylor 1995, 1996). We encounter *neuroeconomics*, which argues for the importance of studying the neurobiological underpinnings of economic behavior such as decision making. We read of *neuromarketing* (Lancet 2004; Lee, Broderick, and Chamberlain 2007; Renvois and Morin 2007; Senior, Smythe, Cooke, et al. 2007); *neuroaesthetics* (Zeki 1993, 1999) which concerns the neuronal basis of creativity and of perceptions of beauty; *neuroergonomics*, which studies brain and behavior at work; *neurophilosophy* (Churchland 1986, 1995); and *neurotheology*, or the neuroscience of belief and spirituality (Trimble 2007).

For some, even the capacity to think ethically, to make moral judgments, is a brain kind of thing (see for example, Greene, Sommerville, Nystrom, et al. 2001; Tancredi 2005; Koenig, Young, Adolphs, et al. 2007). And, reuniting apparent rivals for a knowledge of the human mind, we find *neuropsychanalysis*; proponents always remind their readers that Freud was a neurologist and hoped for just such an integration in his early *Project for a Scientific Psychology* (Bilder and LeFever 1998). We see *neuroeducation*—thus Johns Hopkins University established an initiative bringing together educators and brain science researchers to “magnify the potential for current findings to enrich educational practice,” and the University of London launched its own platform on “educational neuroscience.”¹² We see *social neuroscience*, which, in the words of the journal of that name, “examine[s] how the brain mediates social cognition, interpersonal exchanges, affective/cognitive group interactions

[and] the role of the central nervous system in the development and maintenance of social behaviors.”¹³ Centers, institutes, and laboratories in social neuroscience were established at the Max Planck Institute, New York University, the University of Chicago, UCLA, Columbia University, and elsewhere.

For others, the new brain sciences had important implications for the reform of social policy and welfare (cf. Blank 1999). In 2009, the United Kingdom’s Institute for Government was commissioned by the Cabinet Office to produce a report on the implications of neuroscience for public policy.¹⁴ The following year the nation’s Royal Society—the oldest scientific academy in the world—launched a project called Brain Waves to investigate developments in neuroscience and their implications for policy and for society.¹⁵ In 2009, the French government’s *Centre d’Analyse Stratégique* launched a new program dedicated to inform public policy based on neuroscientific research.¹⁶ And there is much more of the same. Hence, perhaps inevitably given the contemporary ethicalization of biomedical matters, we have seen the rise of a new professional enterprise for worrying about all this: *neuroethics* (Marcus 2002; Moreno 2003; Kennedy 2004; Illes 2006; Farah 2007; Levy 2007). It appears that to understand what is going on when people engage in social interactions with one another, when they feel empathy or hostility, when they desire products and buy goods, when they obey rules or violate laws, when they are affected by poverty or child abuse, when they do violence to others or themselves, and indeed when they fall in love or are moved by works of art, we should turn to the brain.

What are we to make of all this? How has it come about that in the space of half a century the neurosciences have become such a repository of hope and anticipation? How have they emerged from the laboratory and the clinic, and have not only entered popular culture, but have become practicable, amenable to being utilized in practices of government? And with what consequences? We know that there are close linkages between the ways in which human beings are understood by authorities, and the ways in which they are governed. The various psychological conceptions of the human being in the twentieth century had a major impact on many practices: on understanding and treatment of distress; on conceptions of normality and abnormality; on techniques of regulation, normalization, reformation, and correction; on child rearing and education; on advertising, marketing, and consumption technologies; and on the management of human behavior in practices from the factory to the military. Psychological languages entered common usage across Europe and North America, in Australasia, in Latin America, and in many other countries. Psychological training affected professionals from child guidance counselors and social workers to human resource managers. In the process, our very ideas of our selves, identity, autonomy, freedom, and self-fulfillment were reshaped in psychological terms (Rose 1979, 1985, 1988, 1989, 1996, 1999; Miller and Rose 1988, 1990, 1994, 1995a, 1995b, 1997; K. Danziger 1990; Hacking 1995).

Will these developments in the neurosciences have as significant a social, political, and personal impact? If we now consign the Cartesian split of mind and body to history and accept that mind is nothing more than what the brain does, does that mean that neuroscientists, after years of toiling in relative obscurity, are poised to become nothing less than “engineers of the human soul”?¹⁷ It is undoubtedly too early for a considered judgment; it is far from clear what we would see if we were to look back on these events from the twenty-second century. Despite all the grand promises and expectations generated by

neuroentrepreneurs, we cannot know for certain whether any lasting new bodies of expertise will emerge, nor can we foretell the role of neurobiology in the government of conduct across the next decades.

In this book, we abstain from speculation wherever possible. We also seek to distance ourselves from the overgeneralized critiques of ‘neuromania’ and other fundamental defensive reactions from the social and human sciences. For while we raise many technical and conceptual problems with these new ways of thinking and acting, and point to many premature claims and failed promises of translation from laboratory findings to treatments and policies for managing human miseries and ailments, we also find much to appreciate in many of these attempts to render human mental life amenable to explanation and even to intervention.

And, unlike many of our disciplinary colleagues, we do not think that the social and human sciences have anything to fear, provided that they maintain an appropriate critical awareness from our new knowledge of the brain. The *Oxford English Dictionary (OED)* provides a definition of criticism that matches our aims. Rather than fault finding or passing censorious judgment, we are critical here in the sense of “exercising careful judgement or observation; nice, exact, accurate, precise, punctual.” It is in that critical spirit that we aim to describe the new ways of thinking about the nature of the human brain and its role in human affairs that are taking shape, to consider the problems around which these have formed and the conceptual and technical conditions that have made it possible to think in these new ways, and to analyze the ways in which these developments have been bound up with the invention of novel technologies for intervening upon human beings—governing conduct through the brain, and in the name of the brain.

Our Argument

In the course of the intertwined investigations that make up this book, we argue that a number of key mutations—conceptual, technological, economic, and biopolitical—have enabled the neurosciences to leave the enclosed space of the laboratory and gain traction in the world outside. It may be helpful to summarize these here, to help guide readers through the rather detailed analyses contained in the following chapters.¹⁸

Concepts and Technologies

Over the course of the half century that we focus on in this book, the human brain has come to be anatomized at a molecular level, understood as plastic and mutable across the life course, exquisitely adapted to human interaction and sociality, and open to investigation at both the molecular and systemic levels in a range of experimental setups, notably those involving animal models and those utilizing visualization technologies. This has generated a sense of human neurobiology as setting the conditions for the mental lives of humans and societies and shaping their conduct in all manner of ways, many of which are not amenable to consciousness. Each of the major conceptual shifts that led to the idea of the neuromolecular, plastic, and visible brain was intrinsically linked to the invention of new ways of intervening on the brain, making possible new ways of governing through, and in the name of, the brain.

Yet despite the ontological changes entailed, and the emerging belief that so much of who we are as human beings is shaped by nonconscious structures—human thoughts, feelings, desires, and actions—is shaped by nonconscious neurobiological processes, few of those who work in this area believe that humans are mere puppets of their brains, and the emerging neurobiologically informed strategies for managing human conduct are rarely if ever grounded in such a belief. Neurobiological conceptions of personhood are *not* effacing other conceptions of who we are as human beings, notably those derived from psychology. On the contrary, they have latched on to them in the many sites and practices that were colonized by psychology across the twentieth century—from child-rearing to marketing, and transformed them in significant ways. In this way, and through these processes, our contemporary ‘neurobiological complex’ has taken shape.¹⁹ Let us say a little more about some of these developments.

The central conceptual shift that we chart in the chapters that follow is the emergence of a neuromolecular vision of the brain. By this we mean a new scale at which the brain and nervous system was conceptualized, and a new way in which their activities were understood. At this molecular level, the structure and processes of the brain and central nervous system were made understandable as material processes of interaction among molecules in neurons and the synapses between them. These were conceived in terms of their biophysical, chemical, and electrical properties of their constituent parts. At this scale, in a profoundly reductionist approach, despite the recognition that there was much that could not yet be explained, there seemed nothing mysterious about the operations of the nervous system. Mental processes—cognition, emotion, volition—could be explained in entirely material ways, as the outcome of biological processes in the brain, understood as an organ that was, in principle, like any other, even if, in the case of humans and many other animals, it was far more complex than any other organ. While the explanatory gap still remained, and the move from the molecular level to that of mental processes was highly challenging, the dualism that had haunted philosophy and the sciences of mental life increasingly seemed anachronistic.

The project of neuroscience—for it was indeed an explicit project to create interaction between researchers from the whole range of disciplines that focused on the brain, from mathematics to psychology—had as its aim to revolutionize our knowledge of the brain, and in so doing, radically to transform our capacities to intervene in it. One key transaction point was psychiatric pharmacology—that is to say, the development of pharmaceuticals to treat mental disorder. The emergence of this neuromolecular gaze was intrinsically intertwined with the development of psychopharmacology and the increasing resort to drugs for treating people diagnosed with mental illness, first within, and then outside the asylum walls. Many key findings about molecular mechanisms were made in the course of trying to identify the mode of action of those drugs, almost always using animal models. Indeed, we argue that animal models were epistemologically, ontologically, and technologically crucial to the rise of neuroscience. Research using such models focused on the molecular properties of drugs that appeared to act on mental states and behavior, and hence almost inescapably led to the belief that the anomalies in those mental states could and should be understood in terms of specific disturbances, disruptions, or malfunctions in neuromolecular processes. Since the drugs seemed to affect the components of neurotransmission, this led both to the triumph of the chemical view of neurotransmission over the electrical view that had

previously been dominant, and to the belief that malfunctions in neurotransmission underpinned most if not all mental disorders.

The two founding myths of psychopharmacology—the monoamine hypothesis of depression and the dopamine hypothesis of schizophrenia provided ways of organizing these linkages conceptually and technologically. Both have proved mistaken, perhaps fundamentally wrong. However, this ‘psychopharmacological imaginary’ enabled the growth of novel transactions between laboratory, clinic, commerce, and everyday life. In particular, it was linked to the growing associations between the pharmaceutical companies, the neurobiological research community, and the profession of psychiatry. It was associated with many inflated statements about the therapeutic potency of the compounds being produced and marketed, with the growing routinization of the use of psychoactive drugs that claimed to be able to manage the travails of everyday life by acting on the brain, and with the reshaping of distress in ways that might best accord with the vicissitudes of an increasingly competitive and profitable market for pharmaceuticals.

There were, of course, many who were critical of these new relationships. Critics denounced the medicalization of social problems, linked this to an analysis of psychiatry—and in particular of biological psychiatry—as an apparatus of social control, and argued that the profession, its explanatory claims, its diagnostic categories, and its preference for drugs as a first line of intervention, resulted from its capture by the pharmaceutical industry.²⁰ For many of these critics, aware of the doleful history of eugenics, genetic explanations of mental disorders were particularly distasteful. Despite the certainty of psychiatric geneticists that mental disorders had a genetic basis, critics correctly pointed out that the repeated claims that they have discovered ‘the gene for’ schizophrenia, manic depression, and many other conditions were always followed by failures of replication. However as the twentieth century came to close, a radical transformation in the styles of thought that characterized genetics made a different approach possible.²¹ This focused on variations at a different level—at the level of changes in single bases in the DNA sequences themselves, and the ways in which such small variations in the sequence might affect the nature of the protein synthesized or the activity of the enzyme in question, with consequences for susceptibility to certain diseases or responses to particular drugs.

This molecular vision of genomic complexity thus mapped onto the vision of the neuromolecular brain. It thus became possible to move beyond studies of heritability in lineages and families to seek the specific genomic variants and anomalies that had consequences for susceptibility to certain diseases or pathological conditions such as impulsive behavior. One now looks for the variations that increase or decrease the activity of an enzyme, the operation of an ion channel, or the sensitivity of a receptor site, and which, in all their multiple combinations, underpin all differences in human mental functioning, whether these be deemed normal variations or pathologies. Further, one tries to locate them within the environmental or other conditions that provoke or inhibit the onset of such conditions. As we have moved to such a neurogenomics of susceptibilities and resiliencies, new translational possibilities appear to emerge for neuroscience to engage with strategies of preventive intervention in the real world, whether via early identification and treatment of mental disorder or of neurodegenerative diseases, or in enabling preventive intervention to steer children from a pathway that will lead to antisocial behavior and crime.

Alongside psychopharmacology and psychiatric genomics, there was a third pathway, equally significant in our view, for the transactions between the knowledge of the brain and interventions in human lives—the growing belief that, at least when it comes to the human brain, neither structure nor function is inscribed in the genes or fixed at birth. One term had come to designate this new way of thinking—*plasticity*. The neural architecture of the brain was now located in the dimension of time—not just the time of development from fertilization to birth and into the early years of life, but also throughout the life-course, through adolescence, into adulthood, and indeed across the decades. While it had long been recognized that plasticity existed at the level of the synapse—that synaptic connections were constantly formed or were pruned in response to experience—new ideas of plasticity were taken to mean that a wider ‘rewiring’ was also possible. Notable, here, were the results of work on rehabilitation after stroke in humans, and related work with animal models, which showed that the primate brain could remap itself after injury and that this process could be accelerated by neurobiologically informed practices of rehabilitation—an argument that was commercialized in the development of a number of therapeutic methods, often patented by the neuroscientific researchers themselves.

At the other end of life, researchers argued that experience in the very early days and months following birth, perhaps even in utero, shaped the brain in fundamental ways through modifying gene methylation. Epigenetic arguments sought to establish the ways in which experience ‘gets under the skin’ at the level of the genome itself. In particular, it seemed early maternal behavior toward offspring might so shape their neural development to affect not only the behavior of offspring over their whole life span, but also their own maternal behavior. There now seemed to be a mechanism to pass these environmentally acquired characteristics of the brain down the generations. And finally, the long-held dogma that no new neurons were produced after the first years of life was itself overturned with the finding that in humans, neurogenesis or the growth of new nerve cells in the brain, was possible throughout adult life and might be stimulated or inhibited by environmental factors from nutrition to cognitive activity. No matter that many doubts remained about the translation of these findings from animals to humans, and the interpretation of these results. The brain now appeared as an organ that was *open* to environmental inputs at the level of the molecular processes of the genome, shaping its neural architecture and its functional organization, with consequences that might flow down the generations. The implications were clear: those who were concerned about the future of our children, and the conduct and welfare of the adults they would become, needed to recognize, and to govern, these processes of shaping and reshaping our plastic brains.

If these three imaginaries—of pharmacology, neurogenomics, and neuroplasticity—provided pathways linking the work of brain labs to interventions in the everyday world, so too did a fourth: the visual imaginary, associated in particular with the development of powerful technologies of brain imaging. While the skull initially proved an impenetrable barrier to techniques of medical imaging such as X-rays, there were early attempts—notably by Edgar Adrian—to explore the electrical activity of the living brain using electroencephalography (Adrian and Matthews 1934). However, the fundamental shift in the visibility of the living brain was linked to the development of computerized tomography (CT) scanning in the 1970s and magnetic resonance imaging (MRI) in the 1980s. These produced

images of the structure and tissues of the brain that were, to all intents and purpose equivalent to the images produced of any other bodily tissues. They were simulations, of course, not simple photographs, but they were open to confirmation by physical intervention into the imaged tissues.

Two further developments, positron emission tomography (PET) and functional magnetic resonance imaging (fMRI), seemed to produce identical images of something with a very different ontological status—not the *structure* of the brain but its *functioning*, its activity as if a human host engaged in certain tasks or experienced certain emotions. We seemed to be able to see the neural correlates of the activities of mind itself in real time. And once we did, it seemed impossible to doubt that mind is what brain does. As these technologies became more widely available to researchers, thousands of papers were published claiming to identify the neural correlates of every human mental state from love to hate, from responses to literature to political allegiances; by 2011, such publications were appearing at a rate of about six hundred a month. Despite the well-known technical problems, assumptions, and limitations of these technologies, and the fact that they do not speak for themselves and must be interpreted by experts, the images have undoubted powers of persuasion, and their apparent ability to track mental processes objectively, often processes outside the awareness of the individual themselves, have proved persuasive in areas from neuromarketing to policies of child development. The belief that we can see the mind in the living brain, can observe the passions and its desires that seemingly underlie normal and pathological beliefs, emotions, and behaviors, has been a key element in the claim that neuroscience can provide useful information about the government of human beings, the conduct of their conduct in the everyday world.

Governing the Future—through the Brain

We should beware of scientific or technological determinism. Truths and technologies make some things possible, but they do not make them inevitable or determine the sites in which they find a niche. Different societies, cultures, and sociopolitical configurations offer different opportunities for the new brain sciences. Nonetheless, there is one feature of contemporary biopolitics that has proved particularly welcoming to the image of the molecular, visible, and plastic brain—that which concerns the future. Contemporary biopolitics is infused with futurity, saturated with anticipations of imaged futures, with hope, expectation, desire, anxiety, even dread. The future seems to place a demand not just on those who govern us but also on all those who would live a responsible life in the present (O'Malley 1996).

No doubt this widespread sense of obligation to take responsibility for the future is not unique to advanced liberal democracies in the early twenty-first century. Biopolitics, since at least the eighteenth century, has been future-oriented. From earliest politics of the population, governing vitality operates on axis of time and orients to the future, and images of the future are intrinsic to biopolitical thought and strategies from the politics of health in the eighteenth century, to concerns with the degeneracy of the population in the nineteenth century, through the rise of eugenics and the birth of strategies of social insurance in the first half of the twentieth century. Today we are surrounded by multiple experts of the future utilizing a range of technologies of anticipation—horizon scanning, foresight, scenario

planning, cost-benefit analyses, and many more—that imagine those possible futures in different ways, seeking to bring some aspects about and to avoid others. It would not be too much of an exaggeration to say that we have moved from the risk management of almost everything to a general regime of futurity. The future now presents us neither with ignorance nor with fate, but with probabilities, possibilities, a spectrum of uncertainties, and the potential for the unseen and the unexpected and the untoward. In the face of such future authorities have now the obligation, not merely to ‘govern the present’ but to ‘govern the future.’²² Such futurity is central to contemporary problematizations of the brain.

One feature of these imagined futures is the growing burden of brain disorder. Public funding for research in the new brain sciences, not just in the so-called Decade of the Brain but from at least the 1960s, when initiatives such as the Neurosciences Research Program (NRP) were established,²³ has almost always been linked the belief that conquering this new frontier of the brain will, in an unspecified time line, lead to major advances in tackling the burden.²⁴ The idea of *burden*, here, has disturbing resonances for those who know the history (Proctor 1988; Burleigh 1994). Nonetheless, in a very different sociopolitical context than that of eugenics, psychiatrists, lobby groups, and international organizations make dire predictions about the rising numbers of those in the general population who suffer from depression and other mental disorders, not to mention the “dementia time bomb”: a recent estimate was that, in any one year, more than one-third of the population of the European Union could be diagnosed with such a brain disorder (Wittchen, Jacobi, et al. 2011). In the emerging style of thought that we trace in this book, brain disorders encompass everything from anxiety to Alzheimer’s disease, and often include both addictions and obesity—all, it seems, have their origin in the brain. These disorders, the majority of which are undiagnosed, lead to many days lost from work and many demands on medical and other services, costing European economies hundreds of billions of euros.²⁵ The corollary seems obvious: to reduce the economic burden of mental disorder, one should focus not on cure but on prevention. And prevention means early intervention, for the sake of the brain and of the state.

Children are the key—children who are at risk of mental health problems as they grow up. Many pathologies—ADHD, autism, schizophrenia, bipolar disorder, dementias—are now reframed as *developmental* and hence amenable to early detection and ideally to preventive intervention. This logic can then be extended from mental disorders to antisocial conduct, resulting in the attempt to discover biomarkers in the brain or in the genes of young children that might predict future antisocial personality or psychopathy. In this logic, one first identifies susceptibility, and one then intervenes to minimize the chances of that unwanted eventuality coming about, in order to maximize both individual and collective well-being and to reduce the future costs of mental health problems. Earlier is almost always better—as the mantra has it. Earlier usually means during childhood, because the brain of the developing child is more ‘plastic,’ believed to be at its most open to influences for the good (and for the bad)—and hence leads to intensive interventions in the parenting of those thought to be potentially at risk. This is the rationale of “screen and intervene” (Singh and Rose 2009; Rose 2010b). Neuroscientifically based social policy thus aims to identify those at risk—both those liable to show antisocial, delinquent, pathological, or criminal behavior and those at risk of developing a mental health problem—as early as possible and intervene presymptomatically in order to divert them from that undesirable path.²⁶

At the other end of life, many argue for early intervention to forestall the development of Alzheimer's disease and other dementias, which has led to regular announcements of tests claiming to identify those at risk, the rise of the prodromal category of "mild cognitive impairment," the growing number of "memory clinics" to diagnose such brain states and prescribe interventions to ameliorate them, and much research, so far largely unsuccessful, to find effective forms of intervention into the dementing brain (discussed in Whitehouse and George 2008).

In the era of the neuromolecular and plastic brain, those who advocate such strategies think of neurobiology not as destiny but *opportunity*. Many believe that to discover the seeds of problematic conduct in the brain will reduce stigma rather than increase it, despite research showing the reverse (Phelan 2002, 2006). Those seeking biomarkers for psychopathy, even when they believe that there is a clear, genetically based, neurobiological basis for antisocial conduct, argue that neurobiology informs us about susceptibility but not inevitability. Their wish to identify the gene-environment interactions, which provoke vulnerability into frank psychopathy, is linked to a hope for protective strategies, for "the goal of early identification is successful intervention" (Caspi, McClay, Moffitt, et al. 2002; Kim-Cohen, Moffitt, Taylor, et al. 2005; Odgers, Moffitt, Poulton, et al. 2008).²⁷

Interventions sometimes involve behavior therapy, cognitive therapy, and psychopharmaceuticals. But the preferred route to the problematic child—as so often in the past—is through the parents. In the age of the plastic brain, many undesirable neurobiological traits appear to be malleable by changing the ways parents deal with their vulnerable children (Dadds, Fraser, Frost, et al. 2005; Hawes and Dadds 2005, 2007). Such arguments for early intervention have been strengthened over recent years by the proliferation of brain images seeming to show the consequences of early adverse environments on the developing brain of the child (Perry 2008). On the one hand, these images provide powerful rhetorical support for early intervention into the lives of the most disadvantaged families, in the name of the individual, familial, and social costs of the developing brain, and hence future lives, of their children. On the other hand, in situating the origins of all manner of social problems and undesirable forms of conduct so firmly in neurobiology, even in a neurobiology that is itself shaped by environment, we see a repetition of a strategy that we have seen innumerable times since the nineteenth century—to prevent social ills by acting on the child through the medium of the family: a neurobiological explanation for the persistence of social exclusion in terms of a 'cycle of deprivation' grounded in the inadequate parenting provided by the socially deprived.

Economies of the Brain

These arguments about the burden—in this case the economic costs—of brain disorders and the increasing faith in the economic benefits to be gained through strategies of prediction and preventive medicine, have been one important factor for the growth of public investment in neuroscientific research.²⁸ The National Institutes for Health (NIH) in the United States, the equivalent in the U.K. research councils, the European Commission's Framework Programmes, the European Research Council, and the European Science Foundation have all invested in this work, as have private foundations and charitable bodies, such as the

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