The Neuroscience of Freedom and Creativity

Professor Joaquín M. Fuster is an eminent cognitive neuroscientist whose research over the last five decades has made fundamental contributions to our understanding of the neural structures underlying cognition and behavior. This book provides his view on the eternal question of whether we have free will. Based on his seminal work on the functions of the prefrontal cortex in decision-making, planning, creativity, working memory, and language, Professor Fuster argues that the liberty or freedom to choose between alternatives is a function of the cerebral cortex, under prefrontal control, in its reciprocal interaction with the environment. Freedom is therefore inseparable from that circular relationship. *The Neuroscience of Freedom and Creativity* is a fascinating inquiry into the cerebral foundation of our ability to choose between alternative actions and to freely lead creative plans to their goal.

JOAQUÍN M. FUSTER, M.D., Ph.D., is Distinguished Professor of Cognitive Neuroscience in the Brain Research Institute and Semel Institute for Neuroscience and Human Behavior at the University of California, Los Angeles. In the 1950s Professor Fuster pioneered the neurophysiology of cognition. He is the first to have discovered and described "memory cells" in the primate brain. He is the author of numerous peer-reviewed articles and three books: *Memory in the Cerebral Cortex* (1995), *Cortex and Mind* (2003), and *The Prefrontal Cortex* (1980, 4th edition 2008).

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Our Predictive Brain

JOAQUÍN M. FUSTER

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To my younger brother Valentín,
fellow humanist, physician and scientist.

And to the memory of Václav Havel.

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Preface

October 2000, University of Paris, La Salpêtrière Hospital, Charcot Amphitheater. I was invited to give a short acceptance speech on a subject of my choosing after being awarded the Jean-Louis Signoret Prize. Determined to deliver it in French, I gave it an ambitious title: "Liberté et l'Exécutif du Cerveau." In less than half an hour I tried to explain that the prefrontal cortex is the cerebral enabler of the human agenda. Further, that the achievement of biological and social goals is the outcome of the competition between demands of internal and external milieus continuously barraging that cortex. Further, that those demands include unconscious ethical imperatives in addition to instinctual urges. Of course, I dutifully cited Claude Bernard and Benjamin Constant. Human liberty, I concluded, is a phenomenon of the brain's ability to choose, rationally or not, between alternatives of action.

Only after my talk did I realize I had overreached. I had spoken about a sacred French theme in less than perfect French to an intellectual French audience in an august French forum. Now, a dozen years past, this book is an attempt to say all those things better, in English.

What motivates this brain scientist to write about such a lofty theme as human liberty? And what qualifications does he have to do it? He surely must know that the terrain is fraught with pitfalls. Emphatically yes, he knows the dangers. No one has to convince him that those dangers are very real, especially the disdain, or, worse, the implacable wrath, with which modern neuroscience treats the unsuspecting defender of free will.

Indeed, on neuroscientific grounds, the radical defense of free will is a lost cause, and it is not my intention to attempt it. What is defensible – my position here – is that the freedom or liberty to choose between alternatives is a function of the nervous system, especially the cerebral cortex, in its interaction with the environment. Further, that the freedom or liberty to choose between alternatives – including inaction – is relative, constrained by limits in both the organism and its environment. And further, that the subjective experience of freedom is a function of the intensity of the cortical activity that precedes and attends free choice.

A defense of freedom from the determinism of the brain's microcosm of genes and molecules is practically impossible if we ignore that such a microcosm obeys the laws of the nervous system and its environment, and is no less subject to them than the ink is to the written word. Nonetheless, most everybody has a reason to deny liberty a place in that system. No structure within it seems to harbor the immense breadth of human purpose and the biological roots of human institutions. However, even if choice had a specific place in the brain, there would still remain the question of how the brain creates the new from the old. Karl Popper will eloquently win the argument against determinism in human action, but then concede that his victory is insufficient to understand the essence of freedom, responsibility, or creativity. He will wistfully ask himself, now how can we explain Mozart?

Without much success, some philosophers and sociobiologists attempt to anchor liberty beyond the nervous system. Evolutionary psychologists anchor the "illusion of freedom" in the phylogenetic history of mankind, but are seemingly unaware that something truly new has happened in that history to liberate man from his past, to open him to his future, and to make him capable of freely inventing that future. That something is the evolutionary explosion of the cortex of the frontal lobes, especially its prefrontal region.

Aside from the urge to redeem myself after an imprudent speech in French on liberty, what compels me to undertake this intellectual adventure is having devoted nearly half a century to research into that part of the brain. This does not mean that I see

any brain structure, not even the cortex of the frontal lobes, as somehow escaping natural causality or as being endowed with the power to choose and decide for us. Quite the contrary, I view the dynamics of the frontal lobes as ultimately determined by the genome and the environment. Furthermore, the attribution of ultimate executive power to the prefrontal cortex is, as I will explain, a major obstacle to the study of its role in liberty. Yet, because of its prospective functions, that cortex extends the executive freedom of the individual human to shape his future radically beyond the limits of any prior individual animal in the course of evolution.

I must mark for the reader a clear separation between the simplistic notion of the prefrontal cortex as a mythical "CEO in the brain," which it is not, and its central role in the conception and organization of goal-directed actions. This role is composed of several nervous subfunctions, including working memory, preparatory set for action, and inhibitory control. This book is not an apologia for a new theory of the prefrontal cortex to supersede all others. It is, rather, a synthetic view of the processes by which those subordinate functions of the prefrontal cortex, under its overriding function of temporally organizing action, serve our freedom and our ability to create the new, the good, the useful, and the beautiful.

The ultimate foundation of human liberty consists of two cognitive functions that radically differentiate us humans from all other organisms. One is language and the other our ability to predict the future – and to shape our actions accordingly. Language is vastly more than an extension of animal communication. It is a means of imparting information, emotion, experience, and logical thought to ourselves and to others. Because language is also a means of predicting future events (Latin *praedicere*, to foretell) and of constructing plans of action, language and prediction are largely inseparable. The two functions are intimately related to each other, though neither is reducible to the other. One purpose of this book is to explore the nature of that relationship. In any case, both functions stem from the dynamics of a complex adaptive system determined by a finite past but open to an unlimited future. Both language and prediction are solidly based on the workings of the

prefrontal cortex. For this reason alone the prefrontal cortex emerges from evolution as the cradle of liberty.

The vast majority of our daily activities carry success rates of nearly 100 percent. Most of those daily activities, however, are automatic, overlearned, unconscious, and reinforced by repeated previous success. By contrast, our most momentous decisions, that is, those that shape our future (such as career, marriage, emigration, financial investment, new research, or child-bearing), are rarely based on prediction with the highest probability of success, or, conversely, with the lowest risk of failure. It is those momentous decisions that are clearly within the purview of the prefrontal cortex, as the enabler if not the executive of the brain.

Consequently, also in the purview of the prefrontal cortex is all manner of creative or innovative activity in all fields of human endeavor, from the artistic to the social, to the professional, to the scientific, to the philanthropic, to the sporting. In the human agenda success and failure are defined by the attainment of goals not only in biological terms, including health, pleasure, and the absence of pain, but also in terms of values treasured by us humans: love, recognition, trust, credit, esthetic pleasure, praise, social acceptance, and others. Whether and to what extent those values are the result of the sublimation of biological urges is not essential to my present argument. What is essential is that our freedom to pursue them rests on the health and vigor of our prefrontal cortex.

The critical dimension of that temporal-organizing function of the prefrontal cortex, the one that bears on freedom and creativity most directly, is the future. Curiously, almost everybody concerned with frontal functions ignores it, except clinicians and the students of working memory. The first because the planning difficulty of the patient who has suffered injury to the frontal lobe is so glaring, and the second because working memory, for which the frontal lobe is so important, is memory retained to be used in the near future. Everybody else seems afraid to be accused of teleology, that is, of believing that the future can cause the present, which is the nemesis of the physical scientist.

There is another group of scientists, however, who are beginning to see the connection between the future and the prefrontal cortex: the neuroeconomists. The field of neuroeconomics deals

with the role of brain structures in the prediction and probability of *expected* risk and value deriving from free choice – financial reward among others. The prefrontal cortex is one of those structures, heavily implicated in the physiology of choice and liberty. On the one hand, it is profusely endowed with neural detectors of pleasure and reward. On the other, it is endowed with the neural organizers of reward-seeking behaviors (behavioral economics), including the spoken language.

In recent years neuroeconomics has flourished, for the most part as a result of the application of certain conceptual approaches such as game theory, and a better knowledge of the role of the prefrontal cortex in reward and displeasure. Probability has entered animal neuropsychology much as it previously had entered the study of human behavior. Behavioral tests have been devised to measure how animals, especially primates, estimate the probabilities of reward or risk. Thus, neuroeconomics can make reasonably accurate predictions of simple animal decisions, and even correlate those predictions with neural activity. It does not quite come to grips, however, with complex human behavior. And neuroeconomics would fail to do so even if the mechanisms of the human brain were as perfectly understood as they can ever be. Here also, as in market economics, the interplay of variables cannot be predicted with precision. The reason is that interplay takes place in the cerebral cortex, a system of neural networks that is constantly submitted to influences from many sources, all of them different: influences and bias from past memory in the cortex itself, or from the instinctual, visceral, and emotional centers of the limbic brain and the brainstem.

Yet, it is precisely in the crucible of probabilities and uncertainties in the human brain that freedom comes to life. The ability to choose between alternatives literally derives from the variance and degrees of freedom of innumerable variables behind prospective human action. As in evolution, both determinism and straight causality dissolve in probability and, as they do, both yield to a teleological factor: *purpose or goal*.

Much as in liberal economics, the metaphor of the "invisible hand" of Adam Smith (the self-regulating behavior of the marketplace which leads to social good) emerges in the human brain in the

form of imponderable neural influences leading the individual to better adaptation to his environment. Just as innumerable motives move the participants in the marketplace to determine values and prices, innumerable neural influences, some unconscious or merely intuitive, move the individual to make personal decisions. Among those influences are not only the "animal spirits" of biological drive but also the principles of natural law etched in collective evolutionary memory. There are also the principles of esthetics, altruism, and creativity, which are etched in our individual memory by tradition, family, and education – in sum by culture. It is the aggregate of collective and individual memory that allows our prefrontal cortex to invent the future and to make it possible in the present. Here we are going to deal with the functional anatomy of that "invisible neural hand," the memory of the organism in the broadest sense, which makes rational language, prediction, and freedom possible.

This book is primarily the product of my many years of cognitive neuroscience research at the University of California. In close second place, the book is the product of long clinical experience with the mentally ill. The phenomenology of mental illness is one of the best educators on the woeful consequences of the loss of personal freedom. This book is also the product of my earlier European education in the arts and humanities, especially music and languages, those marvelous creative tools that the human brain has bestowed on us. Finally, of course, this book is also the product of endless discussions with my academic colleagues and students at all levels of their development. I am persuaded that some young minds are better at discussing freedom and creativity than many a seasoned scholar with preconceived notions. Perhaps this is true also for other things so very natural and so very human.

To be sure, at times I have thought that the theme of this book is too big for me – perhaps for anybody. There is, indeed, still much we do not know about the brain at the threshold of what is to happen and our freedom to make it happen, or to prevent it from happening. More than once, I have detected a smile on the face of some of my fellow scientists on learning what I have been trying to do. It is a smile faintly revealing a mix of disbelief, compassion, and good wishes. But then, I never lost the sense of

the importance of my task, and many are those who have taken it seriously and have lent me a helping hand with good advice and encouragement. To them, my sincere thanks: Warren Brown, Patricia Churchland, Gerry Edelman, Ignacio Fuster, Patricia Greenfield, Peter Hagoort, Daniel Kahneman, John Schumann, Larry Squire, Peter Whybrow, and others. I owe special thanks to Sally Arteseros for her expert editing of difficult portions of the text, and Carmen Cox for her help in the gathering of references and final preparation of the manuscript.