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Joaquín M. Fuster
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Introduction

I am myself and my circumstance.

José Ortega y Gasset

For as long as it can remember, the human race has been asking itself whether it is the master of its own destiny or, instead, whether human destiny is dictated by stars, deities, or genes. Today, few question anymore that the brain has a great deal to do with destiny. Modern neuroscience, however, is in the main deterministic and reductionistic, averse to the idea that there is a place in our brain for free will or any other sort of "counter-causal" entity.

Yet, thanks to recent advances in cognitive neuroscience, which is the neuroscience of knowledge, that panorama is about to change or is changing already. When it comes to the cognition of human action, both radical determinism and radical reductionism are no longer the beacons to guide our discourse.[1] That does not mean that free will can already claim a sovereign place in the brain in the form of a distinct entity or set of neural mechanisms. What it does mean is that our scientific understanding of the human brain is opening up to accommodate liberty; that is, to

[1] I do not want to be misunderstood. My defense of systems neuroscience makes it appear that I consider basic neuroscience irrelevant to cognition. Quite the contrary, the study of synaptic mechanisms and molecular neurobiology is making enormous strides at the most elementary biophysical stage of neuronal information processing in both learning and memory (Kandel, 2000), without which there is no cognition.

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accommodate our capacity to act as free causal agents, albeit within physical and ethical constraints.

Cognitive neuroscience is beginning to explain our capacity to choose between alternatives of action – which includes inaction – and to extend our ability into the future to cause and to shape our future actions. Certainly this development requires substantial changes in our traditional ways of conceptualizing brain function. Among other things, this book is an attempt to explain those necessary changes. My purpose is to liberate liberty from intellectual limitations, while at the same demarcating the limits of both the brain and human liberty.

There is no persuasive semantic distinction between *liberty* and *freedom*. Some distinctions have been attempted on the basis of contextual usage in different cultures, but such distinctions are superficial and simply boil down to differences in etymology. The root of "liberty" is Latin, whereas that of "freedom" is Anglo-Saxon. In American English the term "liberty" may have gained historical and political currency following the American adoption of the principles of the French Revolution, of which "liberty" was one of the mottos.[2] However, the derivative words from "freedom," such as the adjective, can be more easily used without ambiguities than those from "liberty" to characterize the two most common applications of both words: freedom or liberty *from* and freedom or liberty *to*. In this book I use them without distinction. By doing so, I attempt to open the range of the discussion to bring in subjects like socioeconomics and politics, where one term is favored over the other.[3]

One of the most interesting developments in Western culture is the current convergence of philosophical thinking with neuroscience on the issue of free will. It is useful here to review briefly that issue from the point of view of modern philosophy. This will give us a better perspective on how neuroscience

[2] Thomas Jefferson may have had something to do with this, because before becoming President he had been Minister to France.

[3] At one time I toyed with the idea of entitling this book *The Neurobiology of Liberty* in a somewhat pretentious attempt to parallel it with *The Constitution of Liberty*, which is arguably Hayek's best socioeconomic book (1960).

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approaches the problem of free will, which is my principal agenda.

Immanuel Kant (1724–1804) defended the existence of free will with ethical reasons (1993). To his rationalist mind, morality was inconceivable without free will. William James, a century and a half later, followed the same line of reasoning, but demurred on scientific grounds (James, 1956/1884). The main reason for his hesitancy was the formidable obstacle of determinism, mainly biological determinism. He ended up reluctantly declaring himself an indeterminist, with some tolerance for what he called "soft determinism," which admitted a measure of freedom and responsibility in human choices.

Biological determinism in its extreme form ("hard" determinism) is epitomized by the "demon of Laplace" (Gillespie, 1997) – that is, the idea that *if* we knew *all* the "initial conditions" of the universe, and had limitless computational power, we should be able to predict exactly *all* the behavior of an organism from cradle to death. In other words, we should be able to trace a line of causality through myriad facts and levels of complexity. This position[4] is inimical to modern neuroscience on several grounds, among them the complexity, variance, nonlinearity, and probabilistic nature of neural transactions, especially with respect to psychological phenomena.

The opposite of hard determinism is libertarian free will. This is frequently considered a dualistic (mind/brain) position. In it, free will would be some variant of Bergson's *élan vital* (1907), a kind of extracorporeal entity that infuses us with independence and freedom from physical laws. In recent times, some brain scientists have adopted dualistic positions akin to this one, where the entity is called mind or consciousness – the soul of yore – and endowed with will and control over the brain.[5] As of

[4] In 1814, a somewhat paradoxical position for Laplace, who subsequently became a pioneer of probability theory.

[5] To be sure, those scientists usually envision some kind of "port of entry" of that entity into the executive substrate of the brain. For Sir John Eccles (private correspondence with this author), that port of entry could be the prefrontal cortex, enlarged to incorporate the supplementary motor area (a portion of the frontal lobe's premotor cortex).

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now, neuroscience does not effectively support any dualist point of view. Libertarians also generally oppose this view (Kane, 2011). But some neuroscience, as we will see, is compatible with qualified libertarianism.

Indeed, between those two extremes – determinism and libertarianism – there is a wide range of philosophical positions with which modern neuroscience harmonizes to one degree or another. Almost all of them come under the umbrella of *compatibilism* and have their origin in the philosophy of Thomas Hobbes (1588–1679) (1968). Compatibilism essentially maintains that free will and determinism are compatible, not mutually exclusive. To make that assertion, Hobbes based himself on the evidence that, in the absence of force or coercion, individuals have the ability to make choices in accord with their desires; in other words, to decide on a choice of action *if* there is no physical impediment to it. Generally, compatibilists admit some determinism but deem it irrelevant to human behavior. Many argue for free will on ethical grounds, invoking pragmatic and common-sensical reasons, such as the worthiness of reward or punishment. In this sense, they argue for responsibility more than for free will, though the two are intimately related.

In modern times, Frankfurt and Dennett are among the better-known compatibilists. Beyond their argument for compatibility, both offer fertile ideas for empirical neuroscience. Frankfurt (1971) claims that, in some instances, conflicts develop in a person between the desire to perform an act and the desire not to perform it. Giving the example of the drug addict, he ranks both kinds of desires by order of intensity or priority ("hierarchical mesh"). In the extreme case of the "wanton" addict, where the first-order desire to take the drug prevails in the complete absence of restraint, Frankfurt concludes lack of "personhood" and self-control. There is a plausible neural explanation for the conflict in the "go/no-go" of desired action, which is especially applicable to the addict: the competing prefrontal mechanisms of reward seeking and inhibitory impulse control (Bechara, 2005). In the failure of the latter lies probably the fundamental reason why in the addict free will falls hostage to the habit (Chapters 4 and 7).

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Dennett anchors his concept of free will in evolution (Dennett, 2003). In his view, the will to help others (altruism), for example, is attributable to the evolutionary pressure of kin selection. As we see in the next chapter, freedom evolves *pari passu* with the prefrontal cortex, which at the top of the *perception/action (PA) cycle* relates the organism with the world of others; namely, with the human population.

Among Dennett's many ideas – some adorned with interesting neologisms – the one that seems most treatable by neuroscience is that of temporally staged decision-making. The idea has clear precedents in William James (1956/1884), its originator, and others (Mele, 2006; Poincaré, 1914; Popper and Eccles, 1977). There are numerous variants, but essentially it stipulates that a decision is arrived at in two stages. In the first stage, which may be triggered by random events, possibilities of action are considered with regard to probability of success, outcome, and consequences. Poincaré, the mathematician, had the important insight that some of the trigger events, as well as the process of evaluation itself, may be unconscious. In the second stage, actions are selected for the decision. Robert Kane (2011), a champion of modern libertarianism, limits the intervention of chance and indeterminacy to the very beginning of the first stage, while relegating to the individual what he calls the "ultimate responsibility" (UR). He takes a dim view of some two-stage models because, according to him, they do not respect UR enough; in other words, they are not libertarian enough.

All two-stage models of free will have the inherent problem of almost exclusively relying on feed-forward processing (following the direction of time) with minimal feedback, and only limited room for "changing one's mind." Based on neurobiology, I propose that the model of the PA cycle helps resolve that problem, at least partly. In this model, I place the possibility of chance events anywhere in the cycle; namely, in the external environment, the internal environment, or the brain itself. This implies that an action, and the decision(s) leading to it, can start, and conclude, anywhere in the cycle. It implies that the hypothetical "stages" of free will and decision-making are in effect collapsed, expanded, or alternated in a continuous re-entry of information – between the frontal and posterior cortices.

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Also central to my argument and neural model is the notion that free will – that is, the freedom to take alternative actions – emerges from the intimate relationship between our brain and our environment in the PA cycle. That environment is largely within us, for it includes the internal representations of the world around us. It consists of our perceptual, cultural, and ethical knowledge, in other words, our "personal-world history" – internalized in our cerebral cortex.

The concept of internalized environment was first elegantly outlined in the sociocultural context by the Spanish philosopher José Ortega y Gasset in his 1914 essay (1961), and fleshed out by him in later works. Fred Dretske (2000) recently used a similar concept, directly addressing perception as a fund of acquired personal knowledge. Inspired by Dretske, and suggesting an idea similar to that of my cortical PA cycle, Murphy and Brown (2007) write: "A mental state is a brain-body event relevant to or directed toward a social or environmental context – past, present or future." More to the essence of their thinking and to the subject of this book, they write that mental causation – *ergo* a free mental agency – derives from *categories* of knowledge irreducible to sensory elements or "qualia." With it, they elevate willing causality to the level of what I call the *cognit*.[6]

It is a truism that with our brain we feel free to shape our future and that of others. Behind that truism, however, is the extraordinary evolutionary development of the cerebral cortex, and within it the prefrontal cortex in particular. It is with this knowledge, and after long years of studying this part of the cerebral mantle, that I feel emboldened to embark on this rescue of liberty in the brain. The mission is difficult and requires, above all, intellectual humility, because there are still large gaps in our knowledge. In this book, I attempt to reach and portray what

[6] This is not a capricious neologism. As I explain in Chapter 3, a cognit has the specific meaning of a cortical network, which *is*, itself in the aggregate, a unit of knowledge or memory with all its associated attributes. Although I use the word "representation" frequently in referring to a cognit, that word usage is somewhat loose and imprecise, and does not do full justice to the dynamic nature of the cognit – which is subject to change with learning, attrition from aging, etc. No piece of knowledge or memory ever *re-presents* anything exactly, as juries and judges know.

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Hayek (1952) calls "the explanation of the principle." Here the principle to be explained is how it is that freedom emerges from the functional interaction between the brain and the environment, and what is the position of the prefrontal cortex in that interaction. This explanation of principle may be useful to the brain researcher, the natural philosopher, the jurist, and the medical professional.

It is not too early, however, for me to declare what the book does not do, because it cannot. It does not offer a precise explanation of the brain mechanisms at the cellular level behind the exercise of our freedoms. Nor does it offer anything resembling a computational model or algorithm of that exercise. Complexity, multivariate interactions, and nonlinearity are the main impediments to that explanation.[7]

Any advance in the cognitive neuroscience of liberty requires that we overcome five major hurdles obscuring liberty's positive, optional, and creative force. Above, I have already dealt with some of them from a philosophical perspective. No neuroscientist, I venture, will open this book without one or another of those hurdles in mind: (a) determinism; (b) reductionism; (c) "the central executive"; (d) the hegemony of consciousness; and (e) the hegemony of the "self." Here in this introduction I must address them, however briefly, for the reader to begin to appreciate the real source and power of freedom within ourselves, and the limits to that freedom. At the same time I will advance some concepts that are basic to my approach.

The theory of *determinism* (a) in human behavior applies to the brain the laws of thermodynamics and classical physics. In support of its underlying assumptions is a rapidly increasing mass of genetic, neural, and behavioral facts. With what we know and

[7] This should not mean to anyone, I trust, that the tenets of my model are based on mere intuition. On the contrary, I have made every effort to base every one of those tenets on the best available neuroscience, however fragmentary it may be on certain relevant subjects. In this respect, while my account may not contain uncritical statements, it does contain a measure of generalization or extrapolation. For example, with regard to the PA cycle, what is true for one sensory modality (e.g., vision), I assume to be true for others (e.g., audition and touch; the chemical senses, olfaction, and taste, are more problematic in this respect).

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learn every day about those facts, we feel we are making our way ever closer to the mysteries of the human mind. Since everything in the brain, as in the rest of nature, has causal antecedents, brain science thrives in the hope that only further reduction will reveal those mysteries. For reasons that I will attempt to make clear in this book, that is a fruitless pursuit.

The first serious challenge to general determinism came with the advent of quantum mechanics. With it came the certainty of the uncertain (Popper, 1980; Prigogine, 1997). It is now established knowledge that, especially at the level of the very small, many natural events occur at random within wide margins of variability. Chance and probability have entered the physical world at the most elementary levels, and, at least on theoretical grounds, have fostered the concept that the world and the behavior of humans have become to a large extent unpredictable.[8]

At higher levels, those that really matter in the brain for cognition, we are not dealing with certainties, but rather with possibilities. Game theory, including the evidence that a competing player's strategy makes one's game risky and unpredictable, has added uncertainty to the results of our interactions with others (Glimcher, 2003; Holland, 1998). It is becoming increasingly clear that there is enormous variance in the natural phenomena that lead to, or result from, human behavior. Such variance, regardless of its source, contributes further uncertainty, although it also opens the organism to new possibilities and emergent functions, much as in evolution. Indeed, variance in the brain and in behavior, as in evolution, is what leads to options for selection.

Thus, both randomness and variability are now an integral part of neuroscience. This is especially true of research on the

[8] I say on theoretical grounds, because on empirical grounds there is an enormous distance between uncertainty at the subatomic level and uncertainty in human behavior and neural networks. That distance cannot be bridged with any kind of rational argument beyond the statement of analogy of principles at vastly different levels. In fact, it is highly disputable, though not inconceivable, that Heisenbergian uncertainty at the quantum level leads to behavioral or cognitive uncertainty by a direct causal path. Kane (1985), however, envisioned that path as a possible source of free will.

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cerebral cortex,[9] where all major cognitive functions operate – attention, perception, memory, language, and intelligence. The variance that sensory physiologists encounter in the responses of cortical cells to external sensory stimuli leads them to attribute that variance to noise, accustomed as they are to consistency of response to stimuli with identical physical parameters.[10] In any case, nobody seems yet ready to recognize that, perhaps, among the "degrees of freedom" of statistical variance in the cortex hides one of the reasons for the freedom of the human mind.

Freedom is clearly not reducible to variance, in the brain or anywhere else. But variance, in a complex adaptive system such as the brain, is a necessary condition for plasticity, development, and emergence of new function, all of them conducive to the freedom of cognition and action from determinism. More than metaphorically, variance plays in cognition a role not unlike the one it plays in evolution (Chapter 2). There are three apparent reasons for this. The first is that selection among variants is not only what leads to the emergence of new traits in evolution but also what leads to new patterns of response in the brain. The second is that those patterns are biologically adaptive for the individual as well as for the species. The third reason is that, just as variance leads to changing adaptive relations of the genome with the environment, it also leads to changing adaptive relations of the brain with that environment.

Closer to the action, the role of variance is best illustrated by the prefrontal cortex. The main general function of this cortex is *the temporal organization of goal-directed actions in the domains of behavior, reasoning, and language*. The prefrontal cortex does not

[9] Failure to account for random variability often leads to the inference of chaos and to mischaracterizations of neural causality. Typically, the mechanisms and "specialized" functions of the association cortex have been inferred from *relative* differences in distributions of variance induced by an extrinsic variable. Neither mechanisms nor functions can be reasonably inferred from a partial range of their distribution as demarcated by the effect of any given extrinsic variable.

[10] They ignore the fact that the behavior of brain cells in primary sensory systems conforms to a Poisson distribution, the essential feature of any stochastic (random) process. In association cortex, a large part of the variance in the response of those cells to an external sensory stimulus is attributable to the "history" of that stimulus for the organism.

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perform this function in isolation, but in close cooperation with many other cortical and subcortical structures. It sits at the summit of the PA cycle, deeply embedded in the circuitry of that cycle. In dynamic terms, this means that the prefrontal cortex is subject to myriad inputs from the external as well as the internal world. It also means that it sends vast numbers of outputs to efferent motor systems as well as feedback to input systems. Therein lies its crucial position in freedom and above determinism. My prefrontal cortex is not my "center of free will," but it is the neural broker of the highest transactions of myself with my environment, internal as well as external; that is to say, the highest transactions at the top of my PA cycle (Chapter 4).

At any given time, the specific prefrontal functions are guided if not determined by innumerable inputs in competition with one another, all of them of variable strength. Yet the output of the system is precise and consistent, in the form of a given selected action or series of actions in accord with a goal or set of goals that may be represented, at least in part, in the frontal cortex itself. The reason for this consistency of action despite variance of inputs is that the output is the result of competing averages and probabilities of input, which need not be fixed but can vary within certain ranges to produce the same output. The resulting action is goal-effective if, within limits, it conforms to the representation of the goal. For example, there are many ways to bring the coffee cup to my lips, depending on which muscle groups in my arm I contract in succession to do it. Given my initial position with respect to table and cup, the trajectory of my hand may vary greatly, while reaching out to, as well as bringing in, the cup, yet both actions will be effective if, aided by changing visual and muscle/joint sensory inputs, the end result is the cup against my lips.

The constancy of output despite variations of input obeys a fundamental principle first established in immunology but present in all complex biological systems (Edelman and Gally, 2001): *degeneracy*.[11] Because of it, several different inputs lead to

[11] The word is unfortunate, even if commonly used in immunology, for it implies destruction and entropy. Yet the concept is one of the most fertile in cognitive neurobiology. Degeneracy refers to the classing of inputs or

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