The Force of the Virtual

. . . .

Deleuze, Science, and Philosophy

Peter Gaffney, Editor

University of Minnesota Press
Minneapolis
London

· CHAPTER 10 ·

The Image of Thought and the Sciences of the Brain after *What Is Philosophy?*

Arkady Plotnitsky

The parts of the walls that were covered by paintings of his, all homogenous with one another, were like the luminous images of a magic lantern which in this instance was the brain of the artist.

—Marcel Proust, *The Remembrance of Things Past*

"Casting Planes over Chaos": Philosophy, Science, Art, and the Nature of Thought

In their *What Is Philosophy?* Deleuze and Guattari define thought as a confrontation with chaos. It is their concept and part of their *image of thought*—"the image of thought that thought gives itself of what it means to think."[1] The architecture of this concept and the lineaments of this image are multifaceted and complex. My aim here is to explore those facets of this concept and image that relate to the sciences of the brain—neurology, physiology, psychology, and others. I shall focus primarily on neuroscience, following Deleuze and Guattari's argument in their conclusion to *What Is Philosophy?* ("From Chaos to the Brain"), which extends their concept of thought to a correlative *philosophical concept* of the brain, in their sense of "philosophical concept." A philosophical concept in this sense is not an entity established by a generalization from particulars or "any general or abstract idea" (11–12, 24) but instead a complex phenomenal configuration: "there are no simple concepts. Every concept has components and is defined by them. It therefore has a combination [*chiffre*]. It is a multiplicity. . . . There is no concept with only one component" (16). Each concept is a multicomponent conglomerate of concepts (in their conventional senses), figures, metaphors, particular elements, and so forth, which form a unity or have a more heterogeneous,

if interactive, architecture that is not unifiable. Philosophy, as a particular form of thought's confrontation with chaos, is defined by the invention of new concepts, which is in turn a complex process involving such components as the plane of immanence or consistency, conceptual personae, and so forth. Each such concept is also seen in terms of naming and posing a problem, one of the hallmarks of Deleuze's philosophy, which, from *Difference and Repetition* to *What Is Philosophy?* defines philosophical thinking as thinking by posing problems. While this aspect of thinking equally pertains to science (including mathematics), the confrontation between the *scientific,* rather than philosophical, thought and chaos, is, according to Deleuze and Guattari, defined by the invention of functions and frames of reference, rather than the invention of concepts (117–18). How we pursue science, however, often depends on concepts and images (philosophical, artistic, or other) related to scientific ones that we possess or form—in the case of neuroscience, those of thought itself. The reverse is, of course, equally true because scientific ideas enter and shape the architecture of our philosophical concepts. This essay takes advantage of this reciprocity in the case of Deleuze and Guattari's philosophical thinking and neuroscience. Their concept and image of thought and the corresponding concept of the brain are shaped by neuroscience or biology in general (and other fields of mathematics and science); on the other hand, this concept and image of thought, or the brain, suggest new trajectories, "lines of flight," for scientific thinking about the brain.

The concept of thought as a confrontation with chaos also requires a concept of chaos, even if only as that of the impossibility of forming such an image or concept, as found, for example, in Martin Heidegger or Jacques Derrida. Although potentially relevant to Deleuze and Guattari's argument, this is not their primary understanding of chaos, which they approach by means of a particular and, especially in philosophy, unusual concept and image.[2] According to them, "Chaos is defined not so much by its disorder as by the infinite speed with which every form taking shape in it vanishes. It is a void that is not a nothingness but a *virtual,* containing all possible *particles* and drawing out all possible forms, which spring up only to disappear immediately, without consistency or reference, without consequence" (118). This concept of chaos, *chaos as the virtual,* indeed appears to be essential to our understanding of thought and, hence, philosophy, art, and science. I would argue, however, that thought also confronts other forms of chaos, which require corresponding concepts

of chaos, two such concepts in particular. Both are at least implicit in Deleuze and Guattari's argument, and in any event, adding them allows one to retain and would amplify their argument concerning the nature of thought. The first concept is that of *chaos as chance or disorder,* disorder defined by chance, or chance by disorder. Deleuze and Guattari's definition of chaos, just cited, invokes this concept and suggests or implies that, while chaos is "defined *not so much* by its disorder" (vis-à-vis a void that is a virtual), it might still be defined, at least to some degree, by disorder and, accordingly, chance. The second concept is that of *chaos as the incomprehensible,* mentioned above, which can be traced to the ancient Greek idea of chaos as *areton* or *alogon*—that which is beyond all comprehension. This "concept" disables any possibility of forming a concept or image of chaos, ultimately even as something unimaginable or unconceptualizable, apart from certain traces left by chaos in this sense upon the (phenomenal) world we experience.[3]

Deleuze and Guattari see chaos as a grand enemy but also as the greatest friend of thought and its best ally in its yet greater struggle, that against opinion, *doxa,* always an enemy only, "like a sort of 'umbrella' that protects us from chaos" (202). As they say, "the *struggle against chaos* does not take place without an affinity with the enemy, because another struggle develops and takes on more importance—the struggle *against* opinion, which claims to protect us from chaos itself. . . . [T]he struggle with chaos is only the instrument in a more profound struggle against opinion, for the misfortune of people comes from opinion. . . . And what would *thinking* be if it did not confront chaos?" (203, 208). Philosophy, art, and science are the primary means of this confrontation between thought and chaos, the confrontation through which thought keeps an affinity with chaos and, together with chaos, wages a war *against* opinion: "But art, science, and philosophy require more [than opinion]: they cast planes over chaos. These three disciplines are not like religions that invoke dynasties of gods, or the epiphany of a single god, in order to paint the firmament on the umbrella, like the figures of an *Urdoxa* from which opinions stem. Philosophy, science, and art want us to tear open the firmament and plunge into chaos" (202).[4]

As indicated above, this confrontation between thought and chaos takes a specific form in each of these endeavors: a creation of concepts and planes of consistency or/as immanence in philosophy; a creation of sensations or affects and planes of composition in art; and a creation of

functions and planes of reference or coordination in science. The specificity of the workings of thought in philosophy, art, and science makes them different from each other, and part of the book's project is to develop an understanding of this specificity, most especially in the case of philosophy. And yet, the interrelationships among philosophy, art, and science appear to be equally significant for Deleuze and Guattari, and this significance compels them to develop a more complex—heterogeneous, yet interactive—landscape and history of thought in relation to which each of these fields is positioned.

As it introduces a new concept of the brain, the book's conclusion, "From Chaos to the Brain," also invokes "interferences" between philosophy, art, and science. These interferences make it no longer possible for a given field to maintain its identity as defined by its particular mode of confronting chaos, and make thought enter more complex forms of this confrontation, for example, by shifting it to other modes of thought: philosophy to science, art to philosophy, science to art, and so forth. There are, moreover, interferences that "cannot be localized" or absorbed by a given field "because [at a point of such an interference] each distinct discipline is, in its own way, in relation with a negative"; it says "a No" to itself, but without switching to another field and its alternative mode of confronting chaos (217–18). As a result, even though thought at such points still confronts chaos, this confrontation is no longer enacted by means of art, science, or philosophy, or interactions between or among them. Thought loses the cohesion governed by the "laws" of art, science, or philosophy, or of their (localizable) interferences: the law of affects and planes of composition in art; the law of functions and planes of reference or coordination in science; and the law of concepts and planes of consistency in philosophy. At the same time, however, the emergence of nonlocalizable interferences and their relationships to the brain ("cerebral plane") lead Deleuze and Guattari to an intimation of a different future of thought, still as a confrontation with chaos, but perhaps no longer linked to art, science, and philosophy, and of a different type of people. As they say, "In this submersion [of thought into chaos at an interference point] . . . there is extracted from the chaos the shadow of the 'people to come' . . . mass-people, world-people, brain-people, chaos-people" (218). Indeed, as will be seen, this type of thought may be seen as more primordial (in a logical rather than ontological sense), and it has been Deleuze and Guattari's concern all

along, reflected in their concepts of schizophrenic, nomadic, minor, and related forms of thought.

"The Magic Lantern": Thought-Brain

An unexpected and intriguing part of the book's conclusion is a new conception of the *brain,* which mediates the appearance of the "shadow of people to come" and which appears in an almost sudden shift in Deleuze and Guattari's argument from thought to the brain. "*The brain,*" they say, "*is the junction*—and not the unity—*of the three planes*" through which art, science, and philosophy, each in its own way, cut through chaos and thus help us to counteract the forces of opinion (208). This is an extraordinary conjecture, most especially because it relates art, science, and philosophy to certain specific (although, as yet, not biologically specified) forms of neural functioning of the brain itself. In other words, art, science, and philosophy or, at least, something that *neurologically* defines each as a particular form of the confrontation between thought and chaos, are now seen as more primordial forms of thinking (as more immediately linked to the brain's neural functioning) rather than more mediated products of thought. Opinion, too, or what defines it neurologically, appears to be an equally primordial form of this confrontation, which, however, "blocks" chaos altogether through relatively simple forms of order, rather than continuing to maintain a relation to chaos in the way (real) thought does. The cave paintings may be seen as already manifesting these workings of thought in its confrontation with chaos (at least, artistic thought, but quite possibly also proto-philosophical and even proto-scientific thought) and its struggle, together with chaos, against then prevailing "cave" opinion, as was indeed demonstrated by George Bataille's analysis of the cave paintings as "the birth of art."[5] Could they be seen as *more primordially* manifesting these (primordial) workings of thought or the brain than our art, science, and philosophy do? It would be more accurate to see them as manifesting the same capacities of thought and the brain, given that the corresponding functioning of thought and the brain have to be socially mediated to become art, science, or philosophy qua art, science, and philosophy. They, or opinion, can only be defined as such as cultural practices, even if they arise from particular neurological capacities, linked to affects and planes of composition in art, functions and planes of reference or coordination in science, and concepts and planes of consistency in philosophy. Some cultural

luminous images of a magic lantern which in this instance was the *brain* of the artist."[7] Now, "what are the characteristics of this brain, which is no longer defined by connections and secondary integrations [of the current theories of the brain]?" According to Deleuze and Guattari:

> It is not a brain behind the brain but, first of all, a state of survey without distance, as ground level, a self-survey that no chasm, fold, or hiatus escapes. It is a primary, "true form," as Ruyer defined it: neither a Gestalt nor a perceived form but *form in itself* that does not refer to any external point of view, anymore than retina or striated area of the cortex refers to another retina or cortical area: it is an absolute consistent form that surveys *itself* independently of any supplementary dimension, which does not appeal therefore to any transcendence, which has only a single side whatever the number of its dimensions, which remains copresent to all its determination without proximity or distance, traverses them at infinite speed, without limit speed, and which makes of them so many *inseparable variations* on which it confers an equipotentiality without confusion. . . . The brain is the *mind* itself. (210–11)

The brain is the only "mind," insofar as we understand by "mind" that which is responsible for thought and the very possibility of thought as a confrontation with chaos. It is difficult to assess this extraordinary program (only sketched in very broad strokes by Deleuze and Guattati) as concerns its significance or feasibility for the future of the sciences of the brain. It is also hard to predict what role this type of image of thought as confrontation of chaos, as manifest in art, philosophy, and science, or in their interferences taking us beyond them, and the corresponding view of the brain's functioning will play in the development of these sciences. Deleuze and Guattari offer a *philosophical* concept and a philosophical image of thought and the brain, or a set of such concepts and images, which, a brilliant intuitive guess as it may be, may or may not play such a role. In addition, *What Is Philosophy?* published in 1991, reflects the state of neuroscience two decades ago. These decades have redefined the future of neuroscience, and continue to do so, virtually daily, as I am witnessing while writing this essay, for example, in a recent article by Tianming Yang and Mihael N. Shadlen, "Probabilistic

Reasoning by Neurons," which reports the discovery of this reasoning in primates.[8]

I would argue, however, that Deleuze and Guattari's argument remains relevant. Indeed these new developments suggest that it has become more inviting to consider, for example, when thinking of "*probabilistic* reasoning by neurons," also a remarkable phrase and concept by virtue of locating *reasoning* in neurons. This view is close to Deleuze and Guattari's concept of the brain by virtue of the manifest presence of a confrontation with chaos (here chaos as chance) in this reasoning. I shall return to this particular aspect of the brain's functioning below. As I said, how we pursue sciences of the brain depends on the concept and image of thought we form, which can come either from science itself or from elsewhere. Deleuze and Guattari's image of thought is clearly shaped by modern biology, even if mostly by earlier ideas, such as von Uexkühl's[9] conception of nature, also significant for those current neurological theories that I relate here to Deleuze and Guattari's work.[10] In particular, Deleuze and Guattari use this conception to support their insight that art may be something that begins with the animal, by carving out a territory and constructing the house, creating a habitat (*Umwelt*). These processes are always more than spatiotemporal. They are also qualitative or compositional, enabling the construction of a plane of composition, which is art's way of confronting chaos. "The spider web contains 'a very subtle portrait of the fly,' which serves as its counterpoint" (185). This argument connects the argument of *What Is Philosophy?* to the key aspects and concepts of Deleuze and Guattari's thought developed in their previous work. Indeed, the argument itself is already suggested in *A Thousand Plateaus,* where von Uexkühl's ideas are invoked and the same examples, such as that of the "art" of the *Scenopoetes dentirostris,* are used.[11] Associating the nonhuman animal behavior or experiences of the world just described with *art* is, as I said, a complex question. On the other hand, the relationships between the animal's (human or not) neurological activity and territorializations, reterritorializations, and deterritorializations, in short with a certain ontology that also involves a confrontation with chaos, may prove to be important for neurological sciences. I shall now discuss certain contemporary neurological theories, those advanced by Rodolfo Llinás and by Alain Berthoz, which appear to me to exhibit significant affinities with Deleuze and Guattari's argument concerning thought and the brain in *What Is Philosophy?* and

with their related ideas, in particular, the ontology of thought developed in *Anti-Oedipus* and *A Thousand Plateaus.*

"Lines of Flight": The Brain, Movement, and the Ontology of Thought

Llinás and Berthoz have developed powerful arguments for the significance of physical movement in our understanding of the brain's functioning, which they indeed see as grounded in movement and, hence, action.[12] According to Llinás: "a nervous system is only necessary for multicellular creatures (not cell colonies) that can orchestrate and express active movement—a biological property known as 'motricity.'"[13] I would argue that Llinás's and Berthoz's theories can be linked to Deleuze and Guattari's ontology of thought and, correlatively, to their concept of thought-brain, grounded in the confrontation between it and chaos, as considered here. I shall mostly follow Berthoz's work, which appears to me closer to Deleuze and Guattaris, even though some of Llinás's ideas from the late 1970s on spatio-temporal representation created in the brain are especially relevant to Deleuze and Guattari's ontology of thought that I shall discuss later. Also, Llinás builds his theory in terms of thinking (as "internalized movement" [ix]), which links this theory more immediately to Deleuze and Guattari's argument, while most of Berthoz's theory deals primarily with perception. As will be immediately apparent, however, thinking is equally at stake in his theory, and, according to Berthoz, perception is already thought and indeed thought as a confrontation with chaos.

Berthoz argues that, by focusing primarily on the connectivities within the brain, current neurobiological and neurophysiological theories by and large fail to take into account the motion- and environment-oriented workings of the brain, which he sees as primary and as fundamental to the brain's development, functioning, and evolutionary emergence. Accordingly, Berthoz aims, first, at developing a more rigorous understanding of how nervous systems and the brain explore the world, and how animals move. He grounds his project in the argument that perception is not only and not so much an interpretation of sensory messages but is also an internal *simulation* of action and specifically motion. "*Perception is simulated action,*" he says.[14] This view not only implies that perception and motion are irreducibly interconnected, but also that the former defines the latter because of the definitional "motricity" of the creatures endowed with

nervous systems. One might say that our perception and thought (perception is, again, always thought) are defined by "lines of light," traversing and interacting with chaos. It may well be that the "line" (and specifically straight line) as movement precedes our perception and (this comes first) simulation and, it follows, visual construction of all spatiality, including that of, or related to, (the image of) line itself.[15] Created, traced, and imaged by our movement, the line becomes a "movement-image" that, although perhaps not quite a priori in Kant's sense (only movement itself may be), is prior to and defines our image of space. This precedence is *imaged* by the early history of cinema, as movement-image (*kinematic* image), as considered by Deleuze in *Cinema 1: The Movement-Image,* via Bergson, to whom, as will be seen, Berthoz appeals as well because Bergson, too, thinks that "perception springs from . . . a sort of question addressed to motor activity."[16] A similar argument may be made about motion and temporality, as considered (in the context of post–World War II cinema) by Deleuze in *Cinema 2: The Time-Image,* which takes Kant on time as its philosophical point of departure. Berthoz also invokes Husserl, inevitably (given the "protention" aspect of Husserl's phenomenology of time) although sporadically, and Merleau-Ponty throughout the book, beginning with the introduction of his main thesis, just cited, "*perception is simulated action.*" Berthoz links this view to Merleau-Ponty's insight that "vision is the brain's way of touching ['vision is palpation by gaze']."[17] We construct space and spatiality, or time and temporality, or everything that we construct or dream (including literally), beginning with our (brains') image of movement, *because we move.*

In expressing his preference for "simulation" vs. "representation," Berthoz qualifies that for him "the brain is a simulator in the sense of *flight simulator* and not in the sense of computer simulation" (which Berthoz appears to see as more representational, although one might contest this point).[18] "Flight simulator" is not merely a useful metaphor, for, especially in the context of Berthoz's argument as a whole, it also names a concept, rooted in the idea of motion, "lines of flight." It is also a philosophical concept in Deleuze and Guattari's sense, albeit also transformed by Berthoz into a scientific framework of functions, frames of references, and so forth. As he says: "Simulation means the whole of an action being orchestrated in the brain by internal models of physical reality that are not mathematical operators but real neurons whose properties of form, resistance, oscillation, and amplification are part of the physical world, in tune with the external world" (18).

with their related ideas, in particular, the ontology of thought developed in *Anti-Oedipus* and *A Thousand Plateaus.*

"Lines of Flight": The Brain, Movement, and the Ontology of Thought

Llinás and Berthoz have developed powerful arguments for the significance of physical movement in our understanding of the brain's functioning, which they indeed see as grounded in movement and, hence, action.[12] According to Llinás: "a nervous system is only necessary for multicellular creatures (not cell colonies) that can orchestrate and express active movement—a biological property known as 'motricity.'"[13] I would argue that Llinás's and Berthoz's theories can be linked to Deleuze and Guattari's ontology of thought and, correlatively, to their concept of thought-brain, grounded in the confrontation between it and chaos, as considered here. I shall mostly follow Berthoz's work, which appears to me closer to Deleuze and Guattaris, even though some of Llinás's ideas from the late 1970s on spatio-temporal representation created in the brain are especially relevant to Deleuze and Guattari's ontology of thought that I shall discuss later. Also, Llinás builds his theory in terms of thinking (as "internalized movement" [ix]), which links this theory more immediately to Deleuze and Guattari's argument, while most of Berthoz's theory deals primarily with perception. As will be immediately apparent, however, thinking is equally at stake in his theory, and, according to Berthoz, perception is already thought and indeed thought as a confrontation with chaos.

Berthoz argues that, by focusing primarily on the connectivities within the brain, current neurobiological and neurophysiological theories by and large fail to take into account the motion- and environment-oriented workings of the brain, which he sees as primary and as fundamental to the brain's development, functioning, and evolutionary emergence. Accordingly, Berthoz aims, first, at developing a more rigorous understanding of how nervous systems and the brain explore the world, and how animals move. He grounds his project in the argument that perception is not only and not so much an interpretation of sensory messages but is also an internal *simulation* of action and specifically motion. *"Perception is simulated action,"* he says.[14] This view not only implies that perception and motion are irreducibly interconnected, but also that the former defines the latter because of the definitional "motricity" of the creatures endowed with

nervous systems. One might say that our perception and thought (perception is, again, always thought) are defined by "lines of light," traversing and interacting with chaos. It may well be that the "line" (and specifically straight line) as movement precedes our perception and (this comes first) simulation and, it follows, visual construction of all spatiality, including that of, or related to, (the image of) line itself.[15] Created, traced, and imaged by our movement, the line becomes a "movement-image" that, although perhaps not quite a priori in Kant's sense (only movement itself may be), is prior to and defines our image of space. This precedence is *imaged* by the early history of cinema, as movement-image (*kinematic* image), as considered by Deleuze in *Cinema 1: The Movement-Image,* via Bergson, to whom, as will be seen, Berthoz appeals as well because Bergson, too, thinks that "perception springs from . . . a sort of question addressed to motor activity."[16] A similar argument may be made about motion and temporality, as considered (in the context of post–World War II cinema) by Deleuze in *Cinema 2: The Time-Image,* which takes Kant on time as its philosophical point of departure. Berthoz also invokes Husserl, inevitably (given the "protention" aspect of Husserl's phenomenology of time) although sporadically, and Merleau-Ponty throughout the book, beginning with the introduction of his main thesis, just cited, *"perception is simulated action."* Berthoz links this view to Merleau-Ponty's insight that "vision is the brain's way of touching ['vision is palpation by gaze']."[17] We construct space and spatiality, or time and temporality, or everything that we construct or dream (including literally), beginning with our (brains') image of movement, *because we move.*

In expressing his preference for "simulation" vs. "representation," Berthoz qualifies that for him "the brain is a simulator in the sense of *flight simulator* and not in the sense of computer simulation" (which Berthoz appears to see as more representational, although one might contest this point).[18] "Flight simulator" is not merely a useful metaphor, for, especially in the context of Berthoz's argument as a whole, it also names a concept, rooted in the idea of motion, "lines of flight." It is also a philosophical concept in Deleuze and Guattari's sense, albeit also transformed by Berthoz into a scientific framework of functions, frames of references, and so forth. As he says: "Simulation means the whole of an action being orchestrated in the brain by internal models of physical reality that are not mathematical operators but real neurons whose properties of form, resistance, oscillation, and amplification are part of the physical world, in tune with the external world" (18).

Berthoz uses this idea to argue that "internalization of the properties of the physical world constrains perception, that we perceive the external world through the laws of the physical world [the laws of classical mechanics] integrated within the functioning of neural networks" (175). Even our most basic perceptions are products of complex strategies and calculations that our nervous system must perform to negotiate these constraints and to take its chances in the world. It is worth considering Berthoz's elaboration leading to the fundamental conclusion just cited, which proceeds via von Uexkühl and his "concept of *Umwelt,* or environment," and Merleau-Ponty's commentary on this concept: "for von Uexkühl, *Umwelt* signals the difference between the world as such (*Welt*) and the world as the realm in which this or that living thing exists. It is a transitional reality between the world as it exists for an absolute observer and a purely subjective domain."[19] It would be better to say "the world as it *would* exist for an absolute observer," if such an observer existed, and, as I explain later, still further qualifications are necessary. Berthoz comments on von Uexkühl as follows:

> The sea urchin is an example of an animal that is no more than reflexes and a repertoire of independent synergies; the sea urchin, says von Uexkühl, is a "republic of reflexes" that exists in an *Umwelt* that represents things that are often dangerous but to which it is so well adapted that it truly lives as if there were only one world. Its nervous system contains no image of openness. On the other hand, for higher animals, *Umwelt* is not closure but openness. The world is possessed by the animal. The external world is distilled by the animal which, differentiating sensory data, is able to respond to them with fine motor action; and these differentiated actions are possible only because the nervous system is equipped like a replica of the external world (*Gegenwelt*), like a copy. It is a mirror of the world (*Weltspiegel*). The *Gegenwelt* is itself divided into *Merkwelt,* which depends on how the sensory organs are arranged, the world of perception, and the *Wirkwelt,* which is the world of action. Today it is clear the sea urchin is more than a republic of reflexes, but von Uexkühl's ideas have the benefit of setting the debate.[20]

As indicated previously, the epistemology of the situation appears to be more complex and less mirror-like or realist as concerns the world.

In particular, one can see the *Welt* as the material world, or more accurately, some of its parts, that could be experienced by living creatures as an *Umwelt* in each case (this *Umwelt* can, of course, include other living creatures, each of which has an *Umwelt*). The *Umwelt*, thus, may be seen as *related* to the part of the world with which a particular animal interacts and as the image of this part such a creature constructs in order to act successfully in the world (the *Umwelt* or the *Welt* because at least humans can construct the image or unimage of both). It may not be possible to see this image as a mirror of the world (*Weltspiegel*), invoked by von Uexkühl, or even an image *of* the world (*Welt* or *Umwelt*). By analogy with Deleuze's "movement-image" and "time-image," one might better speak of a world-image or image-world. It may indeed not be possible to use any concept of "world" that we can form, for example as a (single) whole of which only a part can be perceived or engaged with. The "world" may be and appears to be ultimately quite different from whatever image of it we as living creatures, humans or other, can form, including even as the Kantian alterity of things in themselves, the point stressed by Nietzsche from his early work on, including on biological and even neurological grounds. On the other hand, this view is Kantian, as opposed to a Lockean view, insofar as it implies that, even in perception, our *brain mediates and constructs* the (phenomenal) world rather than *immediately perceives it in a mirror-like fashion.* Kant was also aware of the role of the biological machinery involved, especially, given the contemporary developments in biological sciences, by the time of *The Critique of Judgment.* Our interaction with the world also involves a confrontation with the unknowable and even ultimately unthinkable, with chaos as the incomprehensible. Our world-images or image-worlds work and help our actions even under these epistemological conditions, which, however, also complicate our thinking by making us face chance and use probabilistic predictions.

Berthoz indeed links the brain's functioning to prediction. So does, even more centrally but, again, from the same starting point of "thinking as internalized movement," Llinás, according to whom "prediction is the ultimate function of the brain" and the self itself is "*the centralization of prediction.*"[21] Berthoz speaks of "a memory for predicting," again taking one of Merleau-Ponty's insights: "the movement as it is perceived . . . proceeds from its point of arrival to its point of departure."[22] In other words, our movements, as they are perceived, proceed from our estimation of what will happen, which is inevitably probabilistic (although sometimes

close to being certain) to the beginning of our movement or other action. Berthoz then writes:

> Perception is essentially multisensory: it uses multiple, labile frames of reference adapted to the task at hand. It is predictive; receptors detect derivatives, and the brain contains a library of prototype shapes of faces, objects, and perhaps movements and synergies. Nature has devised simplifying laws among the geometric, kinematic, and dynamic properties of natural movements. But the predictive nature of perception is also—perhaps especially—due to memory. For memory is used primarily to predict the consequences of future action by recalling those of past action. (115)

Berthoz discussed, first, how this thesis may be justified by the workings of various types of spatial memory, beginning, via Darwin's remarkable insights, with "navigational memory" (117–20). He then considers the anticipatory and predictive nature of perception, thinking, and knowledge, or action in other key neurological phenomena, such as natural movement, or strategies of capture or other goal-oriented action (such as "the art of braking"). Although these are not Berthoz's primary terms in the book (chance is only invoked briefly as a disruption of the "game of regularity" [255]), or those of Llinás, the argument for the essentially predictive nature of perception or thinking gives chance and probability central roles in our thinking and makes it a confrontation with chaos as chance.[23] "Ours" here may need to be extended well beyond the human. To cite Yang and Shadlen: "Our brains allow us to reason about alternatives and to make choices that are likely to pay off. Often there is no correct answer, but instead one that is favored simply because it is *more likely* to lead to rewards. . . . [We] show that rhesus monkeys can also achieve such reasoning. We have trained two monkeys to choose between a pair of coloured targets after viewing four shapes, shown sequentially, that governed the probability that one of the targets would furnish a reward."[24] Of particular significance here are the neural correlates of this reasoning, in humans and primates alike: the "probabilistic reasoning by neurons" in question was discovered by tracking sixty-four *individual* neurons of the monkeys.

This evidence further supports the argument that taking chances and betting on outcomes, and hence interacting with chaos as chance, is something that our brain does all the time but that our culture is reluctant to

accept at least at the ultimate level.[25] We continue to seek causality behind chance, be it in our brain or mind, nature (dead or alive) or spirit, or God, who does not play dice, as Einstein (thinking of nature) believed or hoped to be the case, although, as one of the founders of quantum theory, he should have known better. In the present view, however, our interaction with and success (individual or collective, including evolutionary) in the world is defined by taking chances, one after another, from one point of a rhizome-like network of events to another. By the same token, our movement in the world is defined by and defines these rhizomes of possibilities, sometimes by using illusions or even hallucinations, to create lines of flight, even though the world, including through movements and actions of our fellow animals (human or other), may channel our rhizomes in particular ways. Indeed, illusions and hallucinations may be all that we may have about the world. Some of these illusions and hallucinations may, however, also lead to material or mental obstacles to others, and thus (along with material obstacles) constrain our motions and actions.

Berthoz regards illusions as solutions and not as errors, taking a cue from Bergson's view, mentioned above, advanced against "the mistake of those who maintain that perception springs from what is properly called the sensory vibration, and not from a sort of question addressed to motor activity" (242).[26] Berthoz contends that "perceptual illusions are solutions devised by the brain to deal with the sensory messages that are ambiguous, or that contradict either each other or the internal assumptions that the brain makes about the external world" and suggests that "illusion is not an error or a bad solution, but rather the best possible hypothesis" (242). Much of the information we have about the world is in fact illusory or, as I shall explain presently, even hallucinatory, rather than real or mirror-like, thus reflecting the presence of chaos behind it (as a virtual field of quickly arising and disappearing forms, and as the incomprehensible), and thus making illusions into thoughts confronting chaos. Berthoz argues, following I. Krechevsky's view of the rats' perception (thinking?), that "'hypothesis' is a situation in which the animal exhibits multifaceted behavior: it is systematic, goal-oriented, to a degree abstract, and not entirely dependent on the immediate environment, either to be undertaken or to be carried out. Finally, [according to Krechevsky]: 'A hypothesis is a person's interpretation of data and not a phenomenon that is derived from the data themselves.' Hypothesis is thus inference, to use Helmholtz's terminology" (243).

Now, Berthoz does differentiate illusions from hallucinations: "Illusion is a solution to an incongruity, to the loss of perceptual coherence [induced primarily, but not only, from the outside]. Hallucination, which is *a creation of the brain [itself]*, is a different story entirely. Hallucination is not the result of sensations that the brain fails to integrate into a coherent perception but of the sudden combination of endogenous memories of perception. In some sense, hallucination is a waking dream, the autonomous functioning of internal circuits that normally work to simulate the consequences of action" (253). As, however, the last sentence suggests, while *different* from illusion, hallucination is actually *not an entirely different story.* Both illusions and hallucinations are part of the *same* story of perception or thought and movement or action told by Berthoz. Indeed hallucinations or, analogously, dreams may be more crucial to it than illusions and perhaps make the latter possible, thus providing a fitting finale to Berthoz's main argument in the book. He adds a brief invective against "architects," who "have forgotten the pleasure of movement" (255–60) and the conclusion, summarizing the book. First of all, both illusions and hallucinations are *hypotheses* because in the case of hallucinations, too, "somewhere in the brain a purely internal activation initiates perceptual hypotheses." Berthoz appeals to an interesting parallel with the painter of Lascaux, which comes, again, courtesy of Merleau-Ponty, invoked on both subjects, Lascaux paintings and perception as a simulation of action as against representation (136). Berthoz writes:

> Like the painter of Lascaux for whom shadows suggested the images of the animals he hunted and that he projected onto the cave walls, here a pathological internal activity triggers the hallucination. Hallucinations are such that they are projected onto the world, *exemplifying a fundamental property of the brain.* Whereas illusion provides the solution to a conflict, *hallucination constitutes clear evidence for the central theme of this book: the anticipatory, projective function of the brain imposes its assumptions and memories on the world, and it reconstructs movement based on the slightest hint of change.* (253; emphasis added)

This is a crucial point. Hallucinations manifest the most fundamental capacity of the brain and its sense of movement, including in its anticipatory (and hence also chance-taking, probabilistic) capacity, and illusion

would itself appear derivative of this capacity, when it is deployed in response to an incongruity. This view may be seen as parallel or even correlative to Deleuze and Guattari's "*schizophrenic*" ontology of thought, productive of hallucinations or illusions and their lines of flights—in the cognitive or thought-ontological sense, rather in a psycho-pathological sense, which, however, is also a manifestation of this ontology, even if a pathological one (not always an easy or unequivocal determination). As I shall suggest below, this more primordial hallucinatory capacity may also be responsible for illusions in the world and our *illusion of* the world. These illusions are our response to the overall incongruence, chaos (as the virtual, as chance and disorder, and as the incomprehensible) of the world that we had to confront in our motion and action already long before we became humans.

From this perspective, the parallel with the painter of Lascaux acquires a greater significance, along the lines of Deleuze and Guattari's view of art in *What Is Philosophy?* Each plane of composition in art is defined "as an *image* of a Universe (phenomenon)"—a cosmos or, to use Joyce's famous coinage, chaosmos, or a constellational assemblage of "affects and percepts"—appearing in the field of thought, in which thought of art intersects with the chaos of forms that are born and disappear with an infinite speed.[27] Thus, there are the universes, "vast planes of compositions" (188), and "composition is the sole definition of art" (191): "Rembrandt-universe [and] Debussy-universe" (177); Monet's "cosmos of roses" (180); the Universes of Klee (184–85), and so forth, from the chaosmoses of cave painters to the art and the beyond-art of "the people to come." It is crucial, however, especially in the present context, that such an image is *not a representation* of any real world, "since no art and no sensation have ever been representational" (193). Instead, it is a hallucination and a simulated action, still in part responding, just as those of cave paintings did, to the incongruous chaos of the world by creating a cosmos or chaosmos, an image of the world—first hallucinatory and then illusionary, although this sequence can be reversed. In this sense, especially if everything begins with movement, art may indeed begin with an animal, and the moving animals of Lascaux may also be allegories of perception as simulated movement. According to Berthoz, building, again, upon Merleau-Ponty: "Perception is not representation: it is [hallucinatory?] simulated action, projected onto the world. Painting is not a set of visual stimuli, but a perceptual action of the painter who has translated, through his gesture in a

limited medium, a code that evokes the scene he perceives, not the scene represented" (136). In Deleuze and Guattari's view of art, this *action* in turn leads to a hallucinatory creation, a "sublime error," of a composition, cosmos or chaosmos, which embodies not representation but what they call percepts and affects, which enable subsequent perceptions or feelings (by which we respond to the work) but are not reducible to them. This "hallucinatory" projection may also be seen in terms of a cinema-like projection of the movement-image on a cave wall, thus also allowing one to speak of our brain as a cinema-brain.

"Dreaming," Berthoz adds, also provides the "essential evidence" of this primordial hallucinatory capacity and activity of the brain (253). This capacity also enables our waking life, although, as it constrains our movement and action, this life of course shapes our hallucinations, forcing us to have illusions to avoid life's incongruities. This argumentation bears crucially on the *relationships* between the Freudian or Lacanian "interpretation of dreams" and theory of desire (as reflecting an Oedipal illusion) and Deleuze and Guattari's schizophrenic, hallucinatory ontology of desire. I stress "relationships" because it is far from clear how avoidable our Oedipal illusion(s) are, even if it may be desirable to live with schizophrenic hallucinations (again, in the thought-ontological sense of Deleuze and Guattari) and alternative illusions they help us to create. In any event, it is remarkable to realize that, while we may move best, most freely and with greatest (infinite?) speed in our dreams, we also dream because we move.

The essentially illusory and hallucinatory nature of our thinking (again, in this general sense rather than referring to medically pathological phenomena) gives a greater, and more Deleuzean, complexity to Berthoz's argument concerning the brain and motion. Berthoz, we recall, takes as his point of departure a view that every moving body must follow the laws of classical mechanics, which compels the brain to invent strategies to make calculations, and, hence, to internalize the basic laws of Euclidean geometry and kinematics. It is true that the animals' movement in the world and the worlds themselves that they, including us, confront and construct are all largely defined and constrained by geometry and classical physics. Such is the case, even though the macro-world in which we exist and of which, having emerged during the long history of dead and then living matter, our bodies (including our brains) are part, is made of atoms. Hence, the ultimate constitution of this world is defined by the laws of quantum physics. Quantum physics was, of course, also developed by us, along with the

understanding of this ultimate constitution as quantum or, as it appears, the ultimate impossibility of understanding of this constitution (chaos as the incomprehensible, as well as chaos as chance because quantum phenomena and correspondingly quantum theory are irreducibly statistical). It is, however, this constitution that ultimately enables our perception and interaction with the world, described by the law of classical physics and simulated as such by our neural machinery. Indeed, one might argue, as Niels Bohr and Werner Heisenberg did, that the whole conceptual structure of, first, Euclidean geometry and then of classical physics, and our corresponding physical-mathematical image of the world, may be seen as arising, via suitable mathematical refinement, from the phenomenal image of the world. This image is created by the brain, as an organ developed in organisms capable of motion, and by the brain's capacities of remembering or, importantly, forgetting the past and predicting the future. One might note that motion is a defining concept of classical physics (in quantum physics, the application of this concept involves significant complexities and may not be possible); and in this sense, classical physics naturally represents our sense of the world, as defined by our sense of movement.[28] In other words, very late in this history our thinking, as a confrontation with the world and its chaosmos, also led to the creation of geometry and classical physics, in this case by slowing the chaos down by means of frames of reference, freeze-frames, and a set of functions to go with it, as considered in *What Is Philosophy?* (117–34). This process itself, however, and other forms of confrontation with chaos, such as by way of proto-art (creating planes of composition and affects or percepts) or proto-philosophy (creating planes of immanence and concepts), are found much earlier.

One might, accordingly, suggest that what, at least, the human brain, as the product of the evolution of moving animals and their brains, creates more primordially is not a *phenomenal world* and ontology *described* by Euclidean geometry and classical physics. Instead, through its multifaceted—art-like, science-like, philosophy-like—interaction with chaos, our brain creates, first, a Deleuzean phenomenal world and (phenomenal) ontology, the world of schizophrenic or rhizomatic possible movements, lines of flight, territorializations and deterritorializations, and so forth.[29] These movements may or may not be actualized or even virtualized (in Deleuze and Guattari's sense), but even when they are, they retain their hallucinatory character. This phenomenal world is, as I have stressed, not a mirror or even an image *of* the "world" as it actually exists, but rather

n image-world or world-image, with the world itself and its existence eyond our image or concept (even beyond that of Kant's "thing in self"). This ontology is largely unconscious and largely illusory, and it generally richer or more complex or stranger than the world we conciously perceive as the physical world, which does not prevent its partial oming into consciousness or its interaction with the material world or reality," or the construction of its (conscious) images. It is the ontology of lesiring machines in motion and in continuous confrontations with chaos the world as what Deleuze and Guattari see as "a body without organs." he latter, in turn, provides both energy resources for our life and forces f resistance to our desires and actions, from basic forms of the reality rinciple, beginning with gravity as a force governing our motion and haping the memory of neurons (responsible for the pleasure and fear of cceleration, vertigo) to the emergence of Oedipal desiring machines.[30] In um, our biological constitution appears to be especially suited for creating this world-image or image-world and succeeds in the world by working vith this image and negotiating with the world through it, again, primarly and inevitably by taking our chances. There is nothing else we can do, ven though we may believe otherwise, in part because sometimes our hances prove to be close to certainty, but *only* close, for nothing is ever bsolutely certain. The "people to come," invoked by Deleuze and Guattari n closing *What Is Philosophy?*—mass-people, world-people, brain-people, haos-people (hence also chance-people)—may prove to be defined by lifferent *forms* of this interaction between the brain and the world, but it vill be defined by them, nevertheless, and thus by the capacity of the brain o make our thought cast planes across chaos, against the never-abating orces of opinion.

The argument just sketched is neurological or cognitive-psychological, ven if only hypothetically so, insofar as it aims to suggest a possible scientific investigation of the brain following upon—this is the *after, après* of my title—Deleuze and Guattari's philosophical ideas here discussed. I ollow not only Llinás and Berthoz, but also Freud, both the early Freud of his *Project for Scientific Psychology* (the ideas of which have acquired new currency in contemporary neuroscience) and the Freud of *Beyond the Pleasure Principle.* Freud started his scientific career by his studies of nerve cells in relatively simple organisms and published articles on this subject before switching to psychotherapy, and he continued to follow the key developments in neurobiology during his lifetime, some of which were

revolutionary. Freud knew that the psychoanalytic situation that he spent a lifetime trying to understand is ultimately defined by our neurological machinery and its interaction with the world, the machinery that creates the mental "world" (hallucinatory in character, in the earlier sense) that both enables and threatens our mental life. He thought that we are better protected against the outside world than against the damage it is capable of inflicting upon itself from within. As he said in *Beyond the Pleasure Principle,* in part devoted to this last vulnerability: "Biology is truly a land of unlimited possibilities. We may expect it to give us the most surprising information and we cannot guess what answers it will return in a few dozen years to the question we have put to it. They may be of a kind which will blow away the whole of our artificial structure of hypotheses."[31] This assessment still applies to our speculations, including the one offered here. Given, however, the intervening developments in biology and neuroscience since this statement, especially those of recent decades and the most surprising information they gave us, Deleuze and Guattari's concept and image of thought may put forward questions that the science of the brain might have to confront. It is even possible that the answers will not blow away the *philosophical* (a more appropriate term than "artificial") structure of this hypothesis, although one can hardly doubt that some of these answers will be surprising.

38. Gilles Deleuze, *The Fold,* trans. Tom Conley (Minneapolis: University of Minnesota Press, 1993) 16–17.

39. Deleuze, *The Fold,* 17.

40. Aronofsky, "Darren Aronofsky: *The Fountain,*" 2.

41. Peter Parks on Wikipage *The Fountain,* http://en.wikipedia.org/wiki/The_Fountain_(film), 5.

42. Deleuze, *The Fold,* 4.

43. Ibid., 4.

44. Patricia Pisters, "Touched by a Cardboard Sword: Aesthetic Creation and Non-Personal Subjectivity in *Dancer in the Dark* and *Moulin Rouge*" in *Discernments: Deleuzian Aesthetics,* ed. Joost de Bloois, Sjef Houpermans, and Frans-Willem Korsten (Amsterdam and New York: Rodopi, 2004).

45. Claire Colebrook, "Mathematics, Vitalism, Genesis," in *A/V Actual/Virtual Journal,* (September 2007) http://www.eri.mmu.ac.uk/deleuze (audio-visual lecture from The Deleuzian Event conference, September 2007).

10. The Image of Thought and the Sciences of the Brain after *What Is Philosophy?*

1. Gilles Deleuze and Félix Guattari, *What Is Philosophy?* trans. Hugh Tomlinson and Graham Burchell (New York: Columbia University Press, 1994), 37.

2. The concept owes its provenance primarily to physics. I have discussed it in "Chaosmologies: Chaos and Thought in Gilles Deleuze and Félix Guattari's *What Is Philosophy?* with Quantum Field Theory."

3. Although I can only mention this point (which I addressed in "Chaosmologies"), chaos as incomprehensible implies the irreducible nature of chance in our interactions with it, and thus the luck of any possible causality hidden behind the appearance of chance. I shall discuss some relationships between these conceptions of chaos later.

4. Of course, there are other creative endeavors, in principle conforming to Deleuze and Guattari's view of thought. It appears, however, that they see philosophy, art, and science as the primary ways in which thought and the brain itself confront chaos. Insofar as other such endeavors represent thought's confrontation with chaos, they could be seen in terms of philosophy, art, and science, or their combinations.

5. Cf. Georges Bataille, *Lascaux: Or, the Birth of Art,* trans. Austrin Wainhouse (Milan: Skira, 1955); and *The Tears of Eros,* trans. Peter Connor (San Francisco, Calif.: City Lights, 1989).

6. Deleuze and Guattari's analysis proceeds in part via Jakob von Uexkühl's work on the artistic-like "technique of nature" (*What Is Philosophy?* 183–86; 232, note 25). This last phrase is Kant's, who gives it a more causal and teleological meaning (*The Critique of Judgment,* 409).

7. Marcel Proust, *The Guermantes Way, The Remembrance of Things Past,* 3 vols., trans. Scott K. Moncrieff and Terence Kilmartin (New York: Vintage, 1982), 435.

8. Tianming Yang and Mihael N. Shadlen, "Probabilistic Reasoning by Neurons," *Nature* 447 (2007): 1075–80.

9. (Jakob von) Uexkühl is generally spelled with the Estonian overlong "ll": Uexkü*ll.* We have chosen to keep the alternate spelling (Uexkühl) because it appears this way in passages cited from both *What Is Philosophy?* and Berthoz's *The Brain's Sense of Movement.*

10. As noted earlier, these connections extend beyond neuroscience or biological sciences, in particular, to Riemann's mathematical ideas concerning spatiality, which, as I shall explain, are also relevant in the present, neurological context. On the role of biology in Deleuze and Guattari, see John Marks's "Molecular Biology in the Work of Deleuze and Guattari," *Paragraph* 29, no. 2 (July 2006): 81–97, and references there.

11. Gilles Deleuze and Félix Guattari, *A Thousand Plateaus,* trans. Brian Massumi (Minneapolis: University of Minnesota Press, 1987), 51, 257, 314–15.

12. Rodolfo R. Llinás, *The I of the Vortex: From Neurons to Self* (Cambridge, Mass.: The MIT Press, 2002), as well as A. J. Pellionisz and R. Llinás, "Tensorial Approach to the Geometry of Brain Function. Cerabellar Coordination via Metric Tensor," *Neuroscience* 5 (1980): 1761–70; and Alain Berthoz, *The Brain's Sense of Movement* (originally published in French in 1997). Berthoz further develops his ideas in *La Décision* (2003).

13. Rodolfo R. Llinás, *The I of the Vortex: From Neurons to Self* (Cambridge, Mass.: MIT Press, 2002), 15.

14. Alain Berthoz, *The Brain's Sense of Movement,* trans. Giselle Weiss (Cambridge, Mass.: Harvard University Press, 2000), 10.

15. Berthoz's research also addresses our perception/conception of the (straight) line, and in particular, the relationships in our brain between the visual system, the motor system, and the vestibular system. These ideas extend insights by Poincaré and earlier work by A. J. Pellionisz and Llinás ("Tensorial Approach to the Geometry of Brain Function"), in turn linked to mathematical ideas of tensors (mathematical objects that transform vectors in space) (*The Brain's Sense of Movement* 37–38, 48–49). (The symmetry of animals' bodies, vis-à-vis plants, is related to these relationships.) See also a beautiful paper by Bernard Teissier, "Protomathematics, Perception and the Meaning of Mathematical Objects" (in Pierre Grialou, Giuseppe Longo, and Mitsushiro Okada, eds., *Images and Reasoning* [Tokyo: Keio University Press, 2005] 135–46). Teissier argues that it may be possible to claim that the evolution of our perceptual systems has created

an isomorphism between the visual line and the vestibular line, and shows the importance of this isomorphism for our concept of the mathematical line.

16. Berthoz, *The Brain's Sense of Movement*, 242.

17. Ibid., 11, 269n.10; quoted from Merleau-Ponty, *The Visible and the Invisible* (translation follows Berthoz's translator).

18. Berthoz, *The Brain's Sense of Movement*, 22, emphasis added.

19. Berthoz, *The Brain's Sense of Movement*, 175; Maurice Merleau-Ponty, *La Nature: notes-cours du Collège de France* (Paris: Seuil, 1995), 220.

20. Berthoz, *The Brain's Sense of Movement*, 175.

21. Llinás, *The I of the Vortex: From Neurons to Self*, ix, 21, 23.

22. Berthoz, *The Brain's Sense of Movement*, 115.

23. This aspect of the argument becomes more pronounced in Berthoz's work on the Bayesian probabilistic reasoning in cognition, on which I comment later (note 25).

24. Yang and Shadlen, "Probabilistic reasoning by neurons," 1075.

25. This thematic is related to the so-called Bayesian approach to probability, which deals with predictions concerning the outcome of individual events (including those we have never confronted before) on the basis of the available information and, hence, memory, rather than on statistical inferences based on frequencies of repeated events. The argument concerning chance and probability given below is essential Bayesian because, for example, every potential move from one point of a rhizome of events and connection to another is always a unique event. Berthoz's group is involved in the "Bayesian Approach to Cognitive Science" project, and his *La Décision* is linked to this problematic as well.

26. According to Berthoz, however, while "Bergson accepts the idea that the brain is used in the internal simulation of movement, . . . he limits its contribution to this mental structuring and refuses to grant that it plays any role whatsoever in the highest cognitive functions that are [according to Bergson] the exclusive domains of the mind" (*The Brain's Sense of Movement* 262). In other words, Bergson's "*movementalism*," as it may be called, which brings him close to Berthoz and Deleuze alike, is ultimately overtaken by his "mentalism," which drives him apart from both.

27. Deleuze and Guattari, *What Is Philosophy?* 65–66.

28. Motion is also an image or concept that we construct, and there have indeed been arguments from Plato on that this image is an illusion, as against either static or some other reality, for example, as in quantum theory, a possible inconceivable "reality" (chaos as the incomprehensible). The image and concept of motion work both in everyday life (consistently with Berthoz's or Llinás's argument) and in classical physics, whose models are (mathematized) idealizations of our phenomenal perception of everyday life. It does not appear possible to use such models in quantum theory: we do not seem to be able to form a useful "illusion" or "hallucination" or to "dream up" the behavior of quantum objects

or of how they give rise to the famously strange quantum phenomena. I have considered this epistemology in *The Knowable and the Unknowable* (29–108).

29. This ontology may be seen as (philosophically) closer to the topological and geometrical ideas of Riemann, which entail a more heterogeneous, yet interactive, and more transformative view of spatiality, and are often invoked by Deleuze and Guattari (e.g., *A Thousand Plateaus*, 482–85). I have discussed the subject in "Manifolds: On the Concept of Space in Riemann and Deleuze." According to Pellionisz and Llinás our brain may function as a tensor-like system that appropriately transforms vectors of our motion (also *The Brain's Sense of Movement*, 48–49). Tensor is a concept developed in Riemannian geometry, especially in relation to the curvature of space, although it can also apply to Euclidean (flat) spaces. As the preceding analysis suggests, the mediation between the workings of our neural machinery and the construction of any phenomenal ontology is immense, and it may never be fully available to a scientific investigation, which can only establish certain correlations and causalities between them. This mediation is essentially at stake in the current discussions and debates in the cognitive and neurosciences. It is not possible to consider the spectrum of positions taken in this regard, and the literature (scientific, philosophical, or popular) on the subject is by now immense. Both Llinás's and Berthoz's arguments are, however, major contributions to these debates.

30. Cf. Gilles Deleuze and Félix Guattari, *Anti-Oedipus: Capitalism and Schizophrenia*, trans. Mark Seem, Helen R. Lane, and Robert Hurley (Minneapolis: University of Minnesota, 1985), 9–16.

31. Sigmund Freud, *Beyond the Pleasure Principle*, trans. James Strachey (New York: W. W. Norton, 1961), 54.

11. Deleuze, Guattari, and Neuroscience

1. Gilles Deleuze and Félix Guattari, *What Is Philosophy?* trans. Hugh Tomlinson and Graham Burchell (New York: Columbia University Press, 1994), 216.

2. Jonathan Moreno, *Mind Wars: Brain Research and National Defense* (Washington, D.C.: Dana Press, 2006); Joseph Dumit, *Picturing Personhood: Brain Scans and Biomedical Identity* (Princeton, N.J.: Princeton University Press, 2003); Brian Massumi, "Fear (The Spectrum Said)" *Positions* 13, no. 1 (2005): 31–48; Elizabeth A. Wilson, "The Work of Antidepressants: Preliminary Notes on How to Build an Alliance between Feminism and Psychopharmacology," *Biosocieties* 1 (2006): 125–31; Steven Rose, *The Future of the Brain* (Oxford: Oxford University Press 2006).

3. Mark Amerika, *Meta/Data* (Cambridge, Mass.: The MIT Press, 2007), 53.

4. Ibid., 32–33.

5. For two examples, see Watson discussing Edelman (Sean Watson, "The Neurobiology of Sorcery: Deleuze and Guattari's Brain," *Body and Society* 4 [1998]: