

# Chapter 1

## Materialism's Eternal Return: Recurrent Patterns of Materialistic Explanations of Mental Phenomena

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**Abstract** Since the new developments of neurotechnologies for studying the brain functioning in the second half of twentieth century, a new wave of enthusiasm for materialistic explanations of mental phenomena has invaded philosophy and psychology departments worldwide. The culmination of all this was the so-called “decade of the brain” in the 1990s. However, a closer examination of the arguments presented by some of these new materialists reveals recurrent patterns of analogies and metaphors, besides an old rhetorical strategy of appealing to a distant future, in which all the problems will be solved. This study intends to show that these new forms of materialism repeat discursive strategies of older versions of materialism, especially the French materialism of the eighteenth century and the German materialism of the nineteenth century. Finally, an interpretation for materialism's eternal return will be offered.

For what can be more harmful to knowledge than falsely communicating even mere thoughts, than concealing doubts which we feel about our own assertions, or giving a semblance of self-evidence to grounds of proof which do not satisfy ourselves? (Immanuel Kant)

When they say that matter is the substance and cause of all the phenomena, but do not give a satisfactorily clear concept either of matter or of the manner in which everything arises from it, then their materialism is little more than unintelligible talk, as dark and incomprehensible as the suprasensual assumptions of their opponents. (Heinrich Czolbe)

For a significant part of our modern society, materialism seems to be the natural and inevitable result of the advancement of scientific research. In fact, this seemingly flawless and often propagated image of an identity between science and the materialist worldview is not without some legitimacy, to the extent that a significant number of scientists make a point of stating their belief in materialism, and devote their time to the popularization of this idea. However, this image does not exactly correspond to reality. Examined more closely, it proves to be very limited and

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problematic, since there are also many scientists who clearly speak out against the materialist worldview, thereby demonstrating the independence of science and materialism.

My aim in this study is to debunk this false identity and to show how it has generated mythical views on human nature, taking as examples the more radical attempts in contemporary neuroscience to eliminate the autonomy of subjective human experience. This usually happens in three steps: initially, some capacities, previously assigned to human beings, are attributed to the brain or part of it; then, a complete physicalization of human nature in general is proclaimed, which is thus reduced to a mere product of the brain activity; and finally, this materialistic view is propagated as the inevitable result of contemporary science.

To achieve the aforementioned goal, this article is divided into four sections. Section 1.1 establishes some conceptual definitions to facilitate both the understanding of our central idea and its subsequent discussion. Section 1.2 shows how a significant part of contemporary neuroscience is committed to materialism and to the promise of a new future for mankind. Section 1.3 shows the great similarity between some arguments of contemporary materialists and the metaphors employed by materialists of the eighteenth and nineteenth centuries, thus characterizing what I call the “eternal return of materialism.” Finally, Sect. 1.4 argues that the uncritical, naïve assimilation and reproduction of contemporary science favors the creation and propagation of myths and ideologies, against which we must be ever vigilant.

## 1.1 Conceptual Definitions

Before setting out the central idea, I will begin with some conceptual clarifications to facilitate both understanding and discussion.

Materialism, though it now appears closely associated with the contemporary image of science, is not itself a scientific theory. In its most general sense, it is a metaphysical thesis about the ultimate nature of reality, which unifies the whole field of human experience, reducing it ultimately to some explanatory principle derived (valid or invalidly) from the concept of matter, and finally providing a worldview. In other words, the hallmark of each and every advocate of materialism is his or her commitment to the thesis that everything that exists in the world is material.<sup>1</sup> However, such a statement is so general and comprehensive that it can never be subjected to any particular empirical test, thus going far beyond the sphere of any possible scientific knowledge. Indeed, at least since Kant’s *Critique of Pure Reason* (1781/ 1998), it is no longer possible to ignore that the totality of the world is just a rational idea, and not an object that can be given in our experience. The same applies to matter, which, if thought of as the ultimate condition of experience,

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<sup>1</sup> One can argue, of course, that there are weaker forms of materialism, according to which there are also numbers and other abstract entities that cannot be reduced to material processes or states. However, in what sense they should be properly called “forms of materialism” is not at all clear to me. In any case, my arguments are directed only to materialism in its stronger forms.

cannot be confused with any particular empirical phenomenon, since in this case it would have to be explained by something other than itself. That is to say, if matter is thought of as the absolute foundation of all human experience, it can never appear as an object of our experience, thus remaining beyond the reach of our scientific knowledge. Therefore, since science must be supported by empirical evidence, no scientific theory, however well established, may imply materialism. And that is exactly why we cannot confuse it with a scientific theory and treat it as if it were one. Therefore, the expression “scientific materialism” can serve at most to designate the ideological stand or the professional status of those who believe in it (scientists), but in no way does this entail that they are proposing a scientific theory. This confusion being unraveled, it should now be clear that the legitimacy of science does not depend on scientists’ commitment to materialism, but only on their commitment to logic and scientific methodology. Thus, it should be noted that all that science can do is to discover the existence of phenomena and their relations, but never the essence and ultimate nature of reality, since this cannot be given in the empirical level and would thus require a different kind of knowledge. Moreover, although scientific practice can be attached to a worldview, as Fleck (1979) and Kuhn (1970) have showed, science is an epistemic activity in constant development, so that its crystallization in a worldview would be contrary to its own nature. In short, materialism and science are different things, which only due to a conceptual mistake can be treated as identical.

This first characterization of materialism is still insufficient to support the central idea of this paper. So it is necessary to introduce a second clarification, which concerns the diversity of ways in which it has appeared in the Western intellectual tradition. In fact, there are specific contextual differences related to the emergence of each type of materialism. But there are also important similarities between its various manifestations. This is what sustains the classic statement of Lange (1866), according to which materialism is as old as philosophy itself. However, as there are many different conceptions of what constitutes the ultimate reality of matter and also of its main explanatory principle, materialism finds different forms of expression over time – not to mention the materialists who do not even present a definition of matter, thus making the term even more vague and comprehensive. Its first manifestation occurs among the ancient Greeks, with the atomism of Leucippus and Democritus, later revived by Epicurus, whose goal was to explain all the reality in terms of size, shape, and motion of atoms in a vacuum. But from the atoms of Democritus and Epicurus to contemporary physics, the term “matter” has taken on a plurality of meanings, which consequently must lead to different kinds of materialism.<sup>2</sup> We should, therefore, always be alert to the different meanings that the terms “matter” and “materialism” may take in contemporary debates – and especially in so far as there are forms of materialism which, in the absence of an explicit concept of matter, rely on a particular physical entity (e.g., brain) or on an explanatory principle (e.g., natural selection). This whole range of potential uses of a single word allows

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<sup>2</sup> The conceptual changes in physics over time offer a good indication of the complexity and the problems involving the notion of matter (Jammer 1961, 1966, 2000).

us to glimpse the broad semantic spectrum of materialism (Bloch 1972; Campbell 1967; Lange 1866; Moser and Trout 1995).

After these initial considerations, I would like to define the type of materialism that I will take as my object of analysis. Leaving aside its more archaic forms, I will focus here on modern materialism, which arose during the second half of the eighteenth century linked to the progress of natural science and remains alive and well in the present (Nieke 1980; Bayertz 2007). Within this context, what specifically interests me here is a kind of materialism associated with contemporary neuroscience, which takes the mind to be nothing but the brain, thus elevating the brain to an omnipotent physical entity and seeking in its properties the fundamental explanatory principle of mental phenomena. In other words, my emphasis will be on materialism not as a general theory of reality, not as a worldview, but only as a strategy for explaining our subjective experience.

## 1.2 Materialism and Contemporary Neuroscience

In the last decades we have witnessed a renewed interest in materialism. A good measure of this fact is the increasing number of recent scholarly books on the subject, which have sought to show both its origins and its relevance to the present (Audidière et al. 2006; Arndt and Jaeschke 2000; Bayertz et al. 2007; Boulad-Ayoub and Torero-Ibad 2009; Moser and Trout 1995). Moreover, in the very field of philosophy of mind, a discipline that deals more specifically with the mind-brain problem, there are several recent attempts to explain the human mind in materialistic terms (e.g., Melnyk 2003; Papineau 2002; Ramachandran 2004; Tye 2009). Not to mention the recent “manifestos” in defense of materialism, which play a broader cultural role, by appealing to a complete conversion of the reader to atheism (Dawkins 2006; Dennett 2006; Harris 2006; Hitchens 2007; Onfray 2005). This renders, in my view, the thesis of a weakening of materialism (Koons and Beeler 2010) highly problematic.

More specifically, we have witnessed a wave of enthusiasm motivated by the continuous and remarkable advances in neuroscience, particularly the new neuroimaging technologies. Inside and outside the universities, new centers of study and/or research of brain processes arise. An explicit optimism underlies this wagering on brain research, seeing in a not too distant future the solution of various problems concerning human nature. We should not lose sight of the enthusiasm with which the international scientific community announced the beginning of “the decade of the brain” (1990–1999) and its promises to the fields of philosophy, psychology, and psychiatry.

Looking more closely at that general enthusiasm, one can see that one of its key features is the fact that its representatives are convinced of living in the dawn of a real revolution in human thought, which will radically transform the vision we have of ourselves. This becomes clear in the statements of some of the most prestigious representatives of contemporary neuroscience and philosophy:

The advent of novel experimental approaches and imaging techniques is sure to transform our understanding of the human brain. What a unique privilege it will be for our

generation—and our children's—to witness what I believe will be the greatest revolution in the history of the human race: understanding ourselves. (Ramachandran and Blakeslee 1998, p. xvii)

Will a proper theory of brain function present a significantly different or incompatible portrait of human nature? Should we prepare ourselves, emotionally, for yet another conceptual revolution, one that will touch us more closely than ever before? [...] I am inclined toward positive answers to all of these questions, and toward an optimistic estimate of our future prospects, both scientific and moral. (Churchland 1996, p. 18-19)

As we investigate, however, the foundations of all this optimism, we find that it relies primarily on a general dissatisfaction with all forms of traditional psychological language (mind, belief, desire, will, intention, etc.) that these authors ascribe to the ingenuity of our Western religious and dualistic tradition. They argue that common sense created illusions that were subsequently corrected by scientific advances (e.g., the case of witches), and the same will likely happen with the advances of neuroscience, which will prove to be a superior theory of human nature. The following passage illustrates this idea:

Psychosis is a fairly common affliction among humans, and in earlier centuries its victims were standardly seen as cases of demonic possession, as instances of Satan's spirit itself [...] That witches exist was not a matter of any controversy. [...] But observable or not, we eventually decided that witches simply do not exist. We concluded that the concept of a witch is an element in a conceptual framework that misrepresents so badly the phenomena to which it was standardly applied that literal application of the notion should be permanently withdrawn. Modern theories of mental dysfunction led to the elimination of witches from our serious ontology. The concepts of folk psychology – belief, desire, fear, sensation, pain, joy, and so on – await a similar fate, according to the view at issue. And when neuroscience has matured to the point where the poverty of our current conceptions is apparent to everyone, and the superiority of the new framework is established, we shall be able to set about reconceiving our internal states and activities, within a truly adequate conceptual framework at last. Our explanations of one another's behavior will appeal to such things as our neuropharmacological states, the neural activity in specialized anatomical areas, and whatever other states are deemed relevant by the new theory. Our private introspection will also be transformed, and may be profoundly enhanced by reason of the more accurate and penetrating framework it will have to work with – just as the astronomer's perception of the night sky is much enhanced by the detailed knowledge of modern astronomical theory that he or she possesses. (Churchland 1988, p. 44-45)

One of the central problems of this kind of materialism is that in the absence of consistent empirical data, its supporters are forced to appeal to a very distant, almost mythical future, in which all their hopes will become reality. Moreover, this appeal to the future is never followed up by a more precise specification of the necessary and/or sufficient conditions for the realization of the announced revolution, or even by spelling out a concrete situation that could falsify its proposal. This raises the suspicion that we are dealing here with mere rhetoric, but in no way with an actual scientific hypothesis.<sup>3</sup> Thus, all that is left for us to believe is a promise with no

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<sup>3</sup> The use of rhetorical strategies in the legitimation of scientific theories seems to be an essential feature of science, as recent studies have shown (Fahnestock 2002; Gross 1996, 2006; Irion 2008; Moss 1993; Shea 2009; Stark 2009). However, this does not entail that science is mere rhetoric or that one can do science with rhetoric alone.

deadline or expiration date. Metaphorically speaking, it is as if we had to buy a promissory note without knowing when we could redeem it. In other words, no more than a prophecy is offered, based only on the hope, or faith, that a revolution will happen in the future. A few decades ago, Popper had already noted the fundamental problem with this materialistic strategy:

Promissory materialism is a peculiar theory. It consists, essentially, of a historical (or historicist) prophecy about the future results of brain research and their impact. This prophecy is baseless. No attempt is made to base it upon a survey of recent brain research. [...] No attempt is made to resolve the difficulties of materialism by argument. No alternatives to materialism are even considered. (Popper 1977, p. 97)

The lack of a solid basis for the materialistic proposal becomes more evident when we analyze its relationship with the advancement of empirical investigations. In fact, after a few decades since the beginning of this general enthusiasm, we can ask if there is by now at least an outline of what should be the new neuroscientific theory of human nature. By way of illustration, in a recent anthology of interviews with some of the foremost scholars of the field – including the leading exponents of contemporary materialism (e.g., Crick, Dennett, and the Churchlands) – we find that after 40 years of neurophysiological research, we still do not have the least idea of how to solve the most basic problems about human consciousness. However, we are not left without guesses and/or general and vague opinions, in most cases incompatible with each other (Blackmore 2006). And when these authors are asked if there is still a long time until the promise can be realized, the most accurate response we receive comes from Patricia Churchland herself: “We don’t really know how long we’ll have to wait” (Churchland and Churchland 2006, p. 56).

Let me explore this point further. While the dreamed future supertheory does not come, what the materialists have to offer is a metaphorical, almost fictional language, through which they attach to the brain or parts of it a series of skills and accomplishments that were previously attributes of human beings as a whole. Thus, the “astonishing hypothesis,” according to which we are just a bundle of neurons or the sum of the behavior of neurons and their molecules, is produced (Crick 1995). And ideas such as “the emotional brain” (Le Doux 1998), “the volitional brain” (Libet et al. 1999), “the executive brain” (Goldberg 2001), “the believing brain” (Gazzaniga 2005), “the brain that changes itself” (Doidge 2009), etc., become possible, too. Let us see some examples of how these metaphors are employed:

My first assumption was that part of one’s brain is concerned with making plans for future actions, without necessarily carrying them out. [...] My second assumption was that one is not conscious of the ‘computations’ done by this part of the brain but only of the ‘decisions’ it makes – that is, its plans. [...] Then, such a machine will appear to itself to have Free Will, provided it can personify its behavior – that is, it has an image of ‘itself’. (Crick 1995, p. 266)

The left hemisphere, in other words, was making emotional judgments without knowing what was being judged. The left hemisphere knew the emotional outcome, but it did not have access to the processes that led up to that outcome. As far as the left hemisphere was concerned, the emotional processing had taken place outside its realm of awareness (which is to say, had taken place unconsciously). (Le Doux 1998, p. 15)

Let me be as clear as I can about what I mean by ‘holding beliefs’ or having belief systems. [...] Overall, and this is my view about the nature of beliefs, our species instinctively

reacts to events, and in a specialized system of the human brain that reaction is interpreted. Out of that interpretation, beliefs emerge about rules to live by. [...] We now know that the left hemisphere of the brain – the one that attaches a story to input from the world – creates these beliefs. [...] It follows from the idea that if the brain is modular, a part of the brain must be monitoring all the networks' behaviors and trying to interpret their individual actions in order to create a unified idea of the self. Our best candidate for this brain area is the 'left hemisphere interpreter'. [...] I have called this area of the left hemisphere the interpreter because it seeks explanation for internal and external events and expands on the actual facts we experience to make sense of, or *interpret*, the events of our life. (Gazzaniga 2005, p. 146–148)

We then discover, not without astonishment, that the pinnacle of our scientific progress consists in replacing the notion of subject with the cerebral hemisphere. Who now “knows,” “makes assessments,” “interprets,” “creates,” “seeks explanation,” etc. is no longer a person but a piece of matter (part of the brain). It turns out that the use of such enchanted metaphors, taken as real explanations of phenomena, produces the opposite result of what was promised, namely, a scientific explanation. After all, we must not forget that analogies and metaphors are valid only when, as well as the manifest similarities, the differences are also highlighted. If the latter disappear, then the relationship becomes one of identity and no longer of analogy.<sup>4</sup> As I tried to show elsewhere (Araujo 2003, 2006), the attribution of real properties and psychological skills to physical objects is characteristic of a very primitive stage of human intelligence, namely, the animism that every materialist wants to combat. And what is worse, this represents a return to a much less critical and more naïve metaphysics than the one they intend to overcome. We are dealing here, therefore, with pseudo-explanations, which in no way address the fundamental issues, and whose function is, again, merely rhetorical.

### 1.3 The Eternal Return

If we add to the analysis so far conducted an historical perspective, this new enthusiasm for the advancement of neuroscience reveals an even more interesting facet, namely, its similarity to certain aspects of earlier versions of materialism, which puts under suspicion the question of its novelty. As stated earlier, the association of materialism with the natural sciences, specifically with physiology, is a phenomenon that arises in the eighteenth century, especially in the context of the French Enlightenment. Later, in the German tradition, by the mid-nineteenth century, it will lead to the so-called “materialism dispute” (*der Materialismusstreit*) (Arndt and Jaeschke 2000; Bayertz et al. 2007; Gregory 1977; Meschede 1980; Wittkau-Horgby 1998).

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<sup>4</sup> One cannot doubt that science has developed with the help of metaphors and analogies (Baake 2003; Brown 2008; Hallyn 2000; Hesse 1966; Leary 1990; Leatherdale 1974), but scientific theories do need far more than figurative language to be established.

Let us consider, first, how the brain is already present in these contexts as the central element in the explanation of mental phenomena:

Since all the faculties of the soul depend so much from the specific organization of the brain and of the whole body, being nothing but this organization itself, we are dealing here with a well enlightened machine! (La Mettrie 1748, p. 70)<sup>5</sup>

All the intellectual faculties, that is to say, all the modes of action attributed to the soul, may be reduced to the modifications, to the qualities, to the modes of existence, to the changes produced by the motion of the brain, which is visibly in man the seat of feeling – the principle of all his actions. [...] This brain moves itself in its turn, reacts upon itself. (Holbach 1770, p. 63)

The operations of the soul or spirit result from movements executed by the cerebral organ. (Cabanis 1805, p. 40)

One cannot doubt that the seat of consciousness, of will, of thought must be finally sought only in the brain. Only that, for now, we have been unable to determine the manner in which the machine gears are interrelated. (Vogt 1847, p. 17)<sup>6</sup>

That the brain is the organ of thought, and that both are in an immediate and necessary relation, that one does not exist and cannot be thought without the other, is a truth which a physician or physiologist can hardly doubt. (Büchner 1855, p. 423)

Even more interesting is the profusion of metaphors and analogies created to explain how the brain can produce what we call mind. There appears here the traditional idea that mental processes are functions or products of brain activity, which is very much alive in contemporary debate<sup>7</sup>:

In the same way as a violin string or a harpsichord key vibrates and gives out a sound, so the strings of the brain, struck by rays of sound, are stimulated to give out or repeat the words which touch them. (La Mettrie 1748, p. 34)

To form an accurate idea of the operations from which thought results, it is necessary to consider the brain as a special organ designed especially to produce it, as the stomach and the intestines are designed to make the digestion, the liver to filter bile, the parotids and maxillary and sublingual glands to prepare the salivary juices. (Cabanis 1805, p. 152-153)

I think that every natural scientist, who thinks in a logical way and with consistency, will come to the conclusion that all those capacities that we apprehend under the concept of mental activities are only functions of the brain substance; or, to express myself here in a more rudimentary way, that thoughts relate to the brain in the same way as the bile to the liver or urine to the kidneys. (Vogt 1847, p. 17)

Thought is a motion of matter. (Moleschott 1852, p. 284)

Just as the steam engine produces motion, the organic complex of evolved matter with energy potential generates in the animal body a sum of effects that, united, we call spirit, soul, thought. (Büchner 1855, p. 443)

These passages, taken here as an illustration only, are enough to show that contemporary materialists, by announcing their ideas as a great novelty, repeat discursive strategies and forms of reasoning very similar to those of their coreligionists in

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<sup>5</sup> For the translations of the French citations, I adopted two different procedures: in the case of Holbach, I used a corresponding English edition of the original work. As for La Mettrie and Cabanis, the translations are all mine.

<sup>6</sup> The translations of the German citations are all mine.

<sup>7</sup> John Searle, for example, in one of his most famous books, has stated: “In my view we have to abandon dualism and start with the assumption that consciousness is an ordinary biological phenomenon comparable with growth, digestion, or the secretion of bile.” (Searle 1997, p. 6).

the past, without being aware thereof. And even though there is no uniformity or consensus between them on what precisely is the brain, as shown by the recent history of neuroscience (e.g., Hagner 2000), it is the general attitude to it – as well as the weakness of the arguments and lack of empirical evidence supporting it – that has been repeated, and that I want here to emphasize. It is as if the entire period of our intellectual history that goes from the second half of the eighteenth century until the late nineteenth century had not existed, so that this new materialistic dawn may sound like something really new. In fact, however, this is just new clothing to old ideas and hopes, which at the end turned into an article of faith. It is this cyclical phenomenon, which appears in our culture over the past three centuries, that I am calling the “eternal return of materialism”.

It is time, however, to ask: is there a meaning in this eternal return? At first, we can understand it only as a theoretical-conceptual naivety, which is due to ignorance or contempt in relation to the history of science and of philosophy. But my thesis is that it reveals something deeper, which concerns a lack of attention to the epistemic limits of human beings. In other words, what materialists are trying to do, at least since the eighteenth century, is to eliminate the autonomy of the subjective dimension of human experience, reducing it or reformulating it in terms of the objective sphere of natural sciences. In the language of contemporary philosophy of mind, this means explaining first person experiences from a third person perspective, an attempt that has so far been proved unsuccessful (Chalmers 1996, 2006; Frank 1995; Henrich 2007; Jackson 1982; Nagel 1974, 1986). Now, the abstraction of the subject in natural sciences is only a methodological tool, useful for the development of robust physical theories, but by no means a proof of its nonexistence or of its irrelevance to the understanding of human nature. It is as if two zoologists, swimming in a lake infested with hungry crocodiles, believed that, by stopping talking of crocodiles, they would be eliminating the imminent danger of being devoured by them. It is precisely this effort to eliminate the realm of subjective autonomy that has failed over time. In this sense, the eternal return of materialism reveals an eternal oblivion: materialists (scientists and philosophers) have forgotten the limits of human knowledge, not just merely of its empirical content, but of its universal conditions. In fact, the subjective experience cannot be eliminated or translated into a purely objective language, although it may be correlated to the latter. In this case, it would be useless to accumulate new empirical data to resolve the impasses and paradoxes of contemporary materialism (Araujo 2003). This allows us to suspect that the new vision of human nature that these materialists want to achieve is perhaps utopian and illusory, since the limits of the conditions for scientific knowledge seem to remain unchanged.

## 1.4 Concluding Remarks

I would like now to explore briefly the question of the relationship between contemporary science and the creation of ideologies. First, it is important to reaffirm that materialism is not a logical and inevitable consequence of scientific research; otherwise,

there could be no antimaterialist scientists. In fact, however, many scientists since the nineteenth century have pointed out the impasses for materialism and the impossibility of solving them (e.g., Du Bois-Reymond 1872; Wundt 1889), and also many prestigious contemporary neuroscientists are antimaterialists (e.g., Beauregard and O'Leary 2007; Eccles 1977, 1980; Penfield 1975; Wallace 2000). Second, the naive and thoughtless exaltation and/or reproduction of a false ideal of science eventually leads to the creation of myths that hamper the understanding of what the scientific activity really is and how it developed historically, and cause scientists themselves to behave unscientifically (Midgley 1994, 2003; Numbers 2009). And it is in this context of an uncritical assimilation of contemporary science that we run the risk of accepting an ideology (scientism, scientific materialism) as if it were a genuine scientific product, and of participating in an ideological crusade without knowing that it is one. Now, if science has a primary function in our society, it consists precisely in the promotion of a critical examination and understanding of reality, not in the creation of fantastic tales and alienating myths. And if we cannot find definitive answers to certain questions that have been consistently raised up over time, this might point to certain limits of our knowledge, which forces us to constantly remind ourselves of the remaining obstacles to avoid the risk of falling into new forms of dogmatism. So, if the dualist metaphysics is only a vestige of our theoretical naivety and of our epistemic ignorance, why should we judge as less naive a doctrine that attributes magical properties to a physical object (the brain) and pin all the future hopes on it, thus creating a new fetish? In contemporary neuroscientific discourse, there seems to be actually less science than one usually imagines.

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