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Cartesian Robotics

IT IS NO SURPRISE THAT a prominent contemporary cognitive scientist would locate René Descartes's fundamental "error" in the philosopher's insistence on the "abyssal separation between mind and body."[1] For the program of cognitive science is arguably the total reduction of the mind to its neurobiological foundation—and this foundation, as Bernard Stiegler, for one, has pointed out, is essentially *machinic* in origin, given the intertwined histories of computing technology and artificial intelligence research, which gave rise to cognitive science itself as a discipline.[2]

Of course, we could just as easily celebrate Descartes as the first cognitive scientist.[3] As most scholars now recognize, Descartes was intensely interested in the physiological foundations of cognition and emotion, elaborating a complex theory of the nervous system and brain while developing a sophisticated medical philosophy.[4] Descartes might be considered one of the earliest "cognitive scientists" because he was the first intellectual to explore systematically the ramifications of the new mechanical philosophy for thinking about embodied human experience. As he wrote in a letter from 1632, "I am now dissecting the heads of various animals, in order to explain what imagination, memory, etc. consist in."[5] Indeed, if Descartes can still be chastised by so many (in the humanities and in the sciences) for holding onto some immaterial, spiritual "substance" as the ground of the "Cartesian subject," it is also the case that prominent figures in the early days of cybernetics, information science, computing, and artificial intelligence (AI) research all looked back to Descartes as a forerunner of mechanized cognition. Norbert Wiener cited Descartes as an early important theorist of automata, noting only that he failed to develop a comprehensive understanding of how the automaton was coupled to its environment.[6] Claude Shannon (key information theorist) and John McCarthy (who coined the term artificial intelligence) praised Descartes's argument that

ABSTRACT This essay looks closely at René Descartes's physiological theory, and especially his theorization of the nerves and the brain as an information-processing system, in order to offer a new interpretation of cognition within his philosophy. Rather than opposing mind and body, Descartes showed how the operations of the soul interrupted the automatic cognitive processes of the body to provide adaptive flexibility for the human organism as a whole. REPRESENTATIONS 124. Fall 2013 © ISSN 0734-6018, electronic ISSN 1533-855X, pages 43–68. DOI: 10.1525/rep.2013.124.2.43.

the body was an automaton, while acknowledging that any effort to understand the brain's function "usually reflects in any period the characteristics of machines then in use." Before the development of "large-scale computers" and the subsequent theorizations of information processing devices, thinkers such as Descartes were limited to hydraulic and other machinery in their modeling of the nervous system.[7]

What the cyberneticians introduced was the idea of an organized being that responded actively to the environment, not through complex "mechanical" interactions, but rather through the introduction of information into the being, which was then reorganized to effect certain actions that would maintain the inherent "purpose" of this being.[8] The finite set of information states was defined by the material organization of the cybernetic entity. Yet the actions were produced by the logic of information, and not mere physical action and reaction. Whether the information system was an analog computer, a physical instrument, or a digital computational device, what was important for cybernetic theory was the fact that an intelligent being (whether artificial or natural) constructed a model of its environment through the coded information received from sensory organs, reorganized that information to preserve its ideal goal state, and then initiated actions that would produce that desired state. In this way, the cyberneticians erased the conceptual distinctions between animal and human, human and feedback machine, and animal and machine, since all were information systems, beings that acted on the basis of virtual, not physical, realities.[9] The measure of human intelligence was the degree of complexity of information processing, hence the interest, in the 1940s and 1950s, in the new large-scale computing devices then being developed. The brain, it was thought, may very well be a digital computer, a logic system that was materially instantiated but governed by the automatic pure logic of binary operations.[10] Despite the shifting metaphors and the progress of technology, the brain is still today understood as a complex machine, inherently computational in function.

To reduce the mind to the technology of the brain, itself modeled on a series of "thinking machines" is, however, to avoid the question of how thinking in the human sense of the term is always predicated on technological prostheses—that which cannot be subsumed into thought but that makes it possible in the first place; for example, memory, social systems, language, inscription, and so on. Therefore technology may well be a form of human artifice, but it is an artifice that grounds the very possibility of human cognition in its highest form. Thinking is therefore a product of our external condition—social, technical, and neurophysiological—but it is not reducible to these conditions. As Stiegler has maintained, drawing on the anthropological insight that cultural evolution displaces biological evolution once human beings "exteriorize" their thinking in social and

technological forms, we must admit that "the human and the tool invent each other."[11]

And so my suggestion is that we must read Descartes from a double perspective, that is, as a thinker interested in intellectual activity that *escapes* all mechanistic explanation and, at the same time, as a thinker who was willing to push to the limit the hypothesis that sensory and advanced cognitive systems (not to mention the passions) had to be understood as complex sites of automatic processes akin to self-governing technological systems. Rather than see this essential tension in Descartes as a contradiction or philosophical failure, I would like to zero in on the *intersection* of these two domains—pure intellect and the body as responsive automaton—to raise the larger question of how to think historically and conceptually about the more fundamental relationship linking humanity with its technology. Or, to put it another way, Descartes's provocative dualism might be read less as an enduring philosophical quandary organized around the relationship between mind and body and more as an expression of a particularly modern question (and challenge), namely, how is human cognition itself *conditioned* by the interplay of minds, bodies, and technologies? Descartes, I will argue, was interested in mapping systematically the unusual machinery of the body, not so much in order to "reduce" aspects of thinking to the actions of that body, but instead to reveal the ways our minds were constantly being shaped and organized by these forms of automatic machinery even as they resisted total determination—as the interventions of what he called "pure intellect" attest. This historicization of the early modern question of cognition and technology can, I think, prepare the way for a critique of the reductionist goals of contemporary neuroscience and cognitive science—without simply rejecting their continuing (and often successful) efforts to understand the nervous system as a form of advanced technology.

I will begin with the nontraditional Descartes, the protocybernetic theorist of automata. Despite Shannon and McCarthy's claim, Descartes was not interested in a mere physics of the nervous system that would be analogous to the analysis of clocks, waterworks, or other intricate physical machines. He in fact noticed the crucial importance of "information" as a competing logic within the physical organization of the body. The threshold notion of information is what will connect the rigorous materialism with the equally persistent spiritualism, body and mind, in Descartes's system.[12] Looking closely at what I will call Cartesian robotics, we can glimpse a novel concept of the human emerging in the seventeenth century. For Descartes, the human body was a robotic information machine that was capable of *interrupting itself.* Read in this way, Descartes's soul might best be understood not as a figure of spiritual and divine transcendence, but instead as a special dimension of the human cognitive automaton, a dimension that was

not easily assimilated to the linear causality of material relations yet was intimately bound to the material organs and structures. With this added dimension, the technical machinery of the human body remained radically open to the outside and thus capable of radical transformation and unprecedented reorganizations. The Cartesian robot was, in essence, a plastic being.

If Descartes as a figure of modern philosophy has been received as a thinker making very specific claims about the human mind in its relationship to bodily experience on the one hand and the divine on the other, in the early modern period these philosophical and theological claims could not be separated from Descartes's much more influential work on physics and physiology. In adopting the mechanical philosophy as a foundational starting point of his investigations, Descartes banished any notion resembling Aristotelian "soul" to explain natural phenomena, including living beings.[13] His most notorious claim was perhaps his denial of any soul in the animal. However, it was through the radical rejection of any organizing principles beyond the interaction of matter itself that led Descartes to a fundamental reconceptualization of the human soul, the human mind that is, and its relationship to the unified organismic body. Since he was committed to a physiological theory that depended on purely mechanical explanation, there was, in the end, no way that he could explain the free and open behavior of the mind. This has usually been understood as the beginning point of Descartes's problematic "dualism," but what is important to note here is that the dualistic approach was predicated on a prior, revolutionary redescription of the animal and human body as a self-governing, mechanically organized entity. For that reason, any discussion of the function of the new form of the soul in Descartes must be framed by his systematic attempt to explain corporeal behavior and corporeal forms of cognition (sensory experience and the like) in opposition to those using categories such as the vegetative, sensitive, or rational soul. This project of Cartesian robotics reveals (in a negative fashion) the key role that the soul will play in his effort to understand the exceptional nature of human identity as something distinct from the explicit technological understanding of animal and human bodies.

We can begin with Descartes's infamous claim that the animal was simply a machine. Descartes, like his early modern contemporaries, was very familiar with automata, and, indeed, robotic machines had been a part of academic and even religious culture for some time.[14] In his *Discours sur la méthode* (*Discourse on Method*)of 1637, Descartes imagined that if someone built a robotic monkey we would not be able to recognize a real creature when confronted with this mechanical version at the same time. And this was for a simple reason—the real creature was itself a robot according to

Descartes, an "automaton," or self-moving machine. Defending this conjecture in a letter the following year, he presented a more elaborate take on this robotic imitation game.

> Suppose that a man had been brought up all his life in some place where he had never seen any animals except men; and suppose that he was very devoted to the study of mechanics, and had made, or helped to make, various automatons shaped like a man, a horse, a dog, a bird, and so on, which walked and ate, and breathed, and so far as possible imitated all the other actions of the animals they resembled, including the signs we use to express our passions, like crying when struck and running away when subjected to a loud noise.[15]

Descartes claims that if this mechanical genius was transported to our own world, he would instantly recognize our animals for what they really are—intricate automata that were just incomparably more accomplished than any of those he had previously made himself. He would be struck, that is, by the genuine resemblance between the real dogs and horses and his own mechanical constructions. If we like to think of animals as "thinking," or having possession of emotions and a soul, it is only because we are, Descartes thinks, deluded by a false analogy. We project our own mental life onto animal actions merely because those actions resemble some of our own. As Descartes argued in his physiological works, as well as in numerous letters in the 1630s, since all animal behaviors could be perfectly explained in purely mechanical terms, there was therefore no need to hypothesize an animal soul: "Since art copies nature, and people can make certain automatons [*varia fabricare automata*] which move without thought, it seems reasonable that nature should even produce their own automatons, which are more splendid than artificial ones—namely all the animals." It was much more astonishing, Descartes claimed, that the human body had a soul, than was the fact that none is found in beasts.[16]

But what about these human automata? Would our imaginary roboticist be fooled into thinking our fellow citizens were merely machines when he arrived in our midst? Descartes says no, for this fabricator would have already faced this challenge back in his own land. "Suppose that sometimes he found it impossible to tell the difference between the real men and those which had only the shape of men." Perhaps initially fooled by his own walking, laughing, crying human robots he would have eventually "learnt by experience that there are only two ways of telling them apart . . . first, that such automatons never answer in word or sign, except by chance, to questions put to them; and secondly, that though their movements are often more regular and certain than those of the wisest men, yet in many things which they would have to do to imitate us, they fail more disastrously than the greatest fools."[17] In a kind of critique of expert systems *avant la lettre*,

Descartes implies that the automaton would inevitably confront a situation for which it was not programmed, so to speak, to handle. But, as he had already noted in the *Discours*, genuine humans arrange their words differently in response to inquiries, and, crucially, they can think their way out of challenging circumstances despite the lack of precedents: "It is unimaginable," he writes, "for a machine to have enough different organs to make it act in all the contingencies of life in the way in which our reason makes us act." Humans, we might say, reveal themselves by their flexibility, their adaptability, their creative capacity: "Reason is a universal instrument which can be used in all kinds of situations."[18] Radical novelty is the domain of the human mind, and therefore the mind cannot be explained in purely mechanistic terms, that is, as a product of linear causality.

Still, it is not immediately clear why even these forms of flexible behavior might not in fact be imitated by a machine of some sort. This is of course the dream of artificial intelligence. Indeed, it is important to keep in mind that Descartes believed mechanical organized bodies were responsible for a great deal of what passes for thinking, in both animals and humans. That is, Descartes was never really interested in the traditional philosophical division between mind and body we now associate with his name, but rather in a more ephemeral transition point between what might be called forms of "corporeal cognition" that were the work of the body and the kind of *pure* intellection that could be performed only by the soul. John Cottingham's term "trialism" attempts to capture the importance for Descartes of this *liminal* zone where body and mind meet, a space rich with its own ontological possibilities, what Descartes might have called "native intelligence."[19]

To understand the importance of this liminal space, we can trace Descartes's own foray into conjectural human robotics, the *Traité de l'homme* (*Treatise of Man*), written around 1630 but never published in his lifetime. Descartes's conceit here is that he will, like his imaginary counterpart, construct (virtually, that is) a human automaton, a machine made up only of physical matter. He will then show that this robotic creature will be able to imitate its real human counterpart in almost every way, demonstrating that the bodies we possess are essentially machines—albeit of divine origin. Descartes's point will be that any action not explained by this virtual robotic simulation must be ascribed to the soul, and not to our bodies. Significantly, Descartes largely dispenses with traditional anatomy in order to delve into the realm of the "unseen," to imagine the hidden mechanisms well beyond our sensory reach.[20] His robotics, in other words, is purely conjectural—he provides a speculative narrative that substitutes for the actual, but unknowable, divine creation. As he later put it, in the *Principia Philosophicae* (*Principles of Philosophy*), "Men who are experienced in dealing with machinery can

take a particular machine whose function they know and, by looking at some of its parts, easily form a conjecture about the design of the other parts, which they cannot see."[21]

Descartes was not only dissecting animals himself regularly, he was also well versed in the medical and anatomical tradition.[22] He was of course not the first to offer a theorization of the nervous system (in fact he borrows heavily here from Galen's standard, if by then outdated, work, as well as the more recent anatomical investigations of Andreas Vesalius and especially Caspar Bauhin), nor was he the first to speculate about how certain mental operations could be localized in specific parts of the brain.[23] However, Descartes took the terminology and concepts of earlier medical and psychological theories and reoccupied them, replacing their ephemeral notions of order and organization with precise, purely mechanical explications. If his anatomical conjectures would soon be rejected, by Thomas Willis most notably, Descartes's methodological revolution nevertheless grounded these new "anthropological" sciences of the brain that emerged in the later seventeenth century.

One of the main purposes of the *Traité*, an exercise in virtual robot construction, is to discover the mechanisms of "self-movement" in the human body, the control systems, in other words, that make possible the continuing integration of the bodily organs and maintain the process of life. If this living being would be the site where we might expect some kind of "soul" to be operating, Descartes goes on to give a surprisingly comprehensive account of how the body persists as an integral, vital being. The key is the nervous system. Descartes will explain how "animal spirits" (for him the most rarified form of particulate matter, that "fine wind"; the term can be traced back to Galen), flowing through small narrow passages in the nervous system and brain, could explain a diversity of rather complex animal (and human) actions.[24] In adopting the mechanistic stance here, Descartes does away completely with the Aristotelian concept of the sensitive or vegetative soul as that which gives form and unity or life itself to matter, thereby opening up *both* a new way to think about the organization of living bodies and a radically new approach to the function of what used to be called the *rational soul*.[25] For Descartes, the rational intellect was something linked to—but radically distinct from—the wholly material organization and process taking place within the automaton.[26]

In a famous passage, Descartes likens the mechanism of the body to the intricate engineering animating the moving statues in the artificial grottoes at the famous royal gardens at Saint-Germain, which operated automatically by means of complicated waterworks.

> And truly one can well compare the nerves of the machine that I am describing to the tubes of the mechanisms of these fountains, its muscles and tendons to divers

other engines and springs which serve to move these mechanisms, its animal spirits to the water which drives them, of which the heart is the source and brain's cavities the water main. Moreover, breathing and other such actions which are ordinary and natural to it, and which depend on the flow of the spirits, are like the movements of a clock or mill which the ordinary flow of water can render continuous.[27]

Crucially, these automata could even react to the presence of visitors via external sensory devices—for example, a visitor unwittingly steps on a particular special stone in order to better glimpse Diana at her bath, and suddenly Neptune appears, wielding his trident.

Descartes plays on this adaptive form of response. For him these automata were essentially cybernetic systems, functioning not according to the rigid, serial logic of the clock but rather following from the flow of information within the system as a totality. The *Traité* was Descartes's attempt to show how myriad bodily functions, including breathing, visual sensation, and reflex actions, could be completely explained by the movement of animal spirits as they passed from sense organ, to nerve, to brain, and then back again to the muscles, without any external "interventions" whatsoever. The automatic mechanism required an internal information system. That is, the "outside" world was converted by the system into an internal coding of sorts that could set in motion new kinds of bodily activity. The act of sensing was a *perturbation* of the system and therefore a prompt for reorganization and action in response to the internal information flow.

We can see that Descartes goes much further than even his mechanical and hydraulic analogies suggest. The body can, he imagined, perform a kind of thinking that greatly exceeded the relatively straightforward (if complex) mechanistic activity of the waterworks. For Descartes, the senses do not merely transmit physical motions through a linear causal chain. Made of exceptionally pliant material, the sense organs are physically imprinted with the movements generated by the external world—like wax imprinted with a seal. The animal spirits (unlike the flow of water in that analogy) can in fact encode real information as they respond to, then transmit, the configurations or textures of the physical environment. That is, in their travels through the body, the animal spirits in the nerves actually form what Descartes describes as ideational patterns emerging from the precise movements of the fragile and responsive organs of sense. These configurations can embody any number of sensible qualities—figure, position, size, distance, but also colors, odors, titillation, and other passions.[28] "These shapes are not the literal analogues of perceived objects," writes one commentator, "rather they constitute a fully arbitrary code embedded in what we now call a virtual function space, or, in Descartes' terms, the corporeal imagination."[29] "There is a code of the senses, antecedent to that of the sensations of the soul united to the

body," as Jean-Pierre Séris concisely puts it.[30] Descartes once depicted this nervous system coding as a series of lines forming endlessly complex geometric figures. The important point is that the code does not need to "represent" the external object in order to transmit these qualities where they will then be experienced by the soul as actual qualities of sensations.

How is this sensory process performed? This coded information is eventually inscribed on the "common sense," that venerable cognitive function now located precisely by Descartes (and thereby newly materialized) in the infamous pineal gland deep within the brain.[31] There, Descartes will say, the information can be "read" (or better "felt") by the intellectual soul. Because sensory information can be transmitted as a wave through the animal spirits instantaneously through the nerves, the state of the sensory organs is immediately doubled within the pineal gland, the center of all the nerve channels in the brain.[32] More important, I think, is that even at this first level of organization the information system has its own *internal economy*. The body manipulates and reorders this information to effect certain activities. Reflex action—the body moving away from the fire, the hands positioned to protect against a sudden fall—is just the result of a movement of information through the nerves to the brain and back down to the muscles, where the action finally occurs, "without any mental volition, just as it would be produced in a machine."[33]

The point I want to stress here is that Descartes describes an information system that is not strictly dependent on linear physical causality, as in the workings of a complex clock or even waterworks.[34] The flow is governed by pattern, not the actual physical qualities of the animal spirits or nerve tubes—which are only really the medium of a flow. The implications are absolutely crucial. All cognitive reality is for Descartes a *virtual reality*. That is, the body constructs a coded model of its environment that is not at all strictly speaking representative. In fact, according to Descartes, a code or sign can only function properly because it is *not* representative. The sensory system is not a more or less neutral medium for knowledge of the external world. The nervous system actively constructs its own virtual reality based on relevant aspects of the world imprinted on the sense organs as a pattern and then synthesized by the common sense into an integrated whole. Hence the possibility of radical deception. Nothing illustrates this better than Descartes's discussion of the phantom limb phenomenon:

> A girl with a seriously infected hand used to have her eyes bandaged whenever the surgeon visited her, to prevent her being upset by the surgical instruments. After a few days her arm was amputated at the elbow because of a creeping gangrene, and wads of bandages were put in its place so that she was quite unaware that she had lost her arm. However she continued to complain of pains, now in one then in another finger of the amputated hand.

The only possible reason for this is that the nerves which used to go from the brain down to the hand now terminated in the arm near the elbow, and were being agitated by the same sorts of motion as must previously have been set up in her hand, so as to produce in the soul, residing in the brain, the sensation of pain in this or that finger. And this clearly shows that pain in the hand is felt by the soul not because it is present in the hand but because it is present in the brain.[35]

The example of pain is revealing. For Descartes, this actual feeling of being cut by a sword, say, is "completely different from the local motion of the sword or the body that is cut—as different as color or sound or taste."[36] Sensations, passions, these are all part of a virtual reality created by the information order that is the nervous system. That reality can be organized and reorganized by the imagination, which was strictly a corporeal faculty for Descartes.

Cognition is the connection and manipulation of this virtual reality, and for that reason is not limited to any one specific temporal configuration. Indeed, for Descartes it is memory that introduces the greatest complexity into this corporeal form of cognition and which truly distinguishes the information machine—a body with a nervous system—from the cruder example of the waterworks. With memory (first described by Descartes in the *Traité de l'homme* as actual patterns formed by physical "holes" in the brain, then later as structural "folds") the body becomes capable of ever more complex actions, because it is responding not just to present stimuli but to past experiences as well at the same time.[37] In a Pavlovian moment, Descartes writes to Marin Mersenne at the time he was writing the *Traité*: "if you whipped a dog five or six times to the sound of a violin, it would begin to howl and run away as it heard that music again."[38] A better example of this temporal complexity is the act of recognition. When we see, for example, just a part of a face or an imperfect representation of something we are already familiar with, Descartes argues that the opening of these specific pores in the brain would trigger automatically the other ones normally associated with these impressions, because there is a physiological association concretely embedded into these memory traces. Thus the soul can literally "see" the whole face or image presented in the imagination, thereby recognizing the person or object despite the existence of only minimal trace perceptions.[39]

This all leads to a rather startling admission by Descartes: if the automaton is outfitted with a memory system, he says in the *Traité de l'homme*, "without there being any soul in this machine, it can be naturally disposed to imitate all the movements that real men (or many other, similar machines) will make when the soul is present."[40] What Descartes seems to be saying is that the delayed effects of the memory structure, the persistence of information even after the original physical movements have dissipated,

make possible a kind of simulation of the interventional capacity of the soul.[41] Memory disrupts the current flow of information in the system, and thus allows the robotic machine to act (at least in the view of the spectator) in a seemingly flexible and adaptive manner. The body can, in some circumstances then, imitate the behavior of the genuine human, defined here as the union of body and soul—a problem that Descartes promises to address, but unfortunately the version of the text we have is incomplete on that score.

The question, then, is what exactly distinguishes the work of the soul from the cognitive functioning of the complex nervous system? Or to put it another way, what is the possible advantage for the body of having such a soul? The soul (from the robot's perspective that is) represents an advantage that is enabled by a *new* form of response to the environment, a form of behavior that exceeds the cognitive system, structured to this point by complexes of sensory information and their internal organization and reorganization (what Descartes calls memory and imagination). Unlike the animal, governed by the relentless logic of experience (including memory), the human body can escape that logic through the interventions of the intellect. The rational soul is both inside and outside this automatic system: it will have, he says, "its principal seat in the brain, and reside there like the fountain-keeper who must be stationed at the tanks to which the fountains' pipes return if he wants to produce, or prevent, or change their movements in some way."[42] It is crucial to see that the question of the soul's activity is situated within the physiological space of integration, synthesis, and memory—namely, the brain and, specifically, the pineal gland. The question of the soul is the question of how that space can be radically disrupted (that is interrupted) from *within* its own economy and logic.

This question haunts one of Descartes's earliest works on thinking, the *Regulae ad Directionem Ingenii* (*Rules for the Direction of the Mind*; ca. 1628). Here we see him moving away from traditional rhetorical and logical methods of discovery, methods that were essentially discursive and often syllogistic, toward a new cognitive model of understanding that privileged the immediacy of what he called *intuition*.[43] For Descartes, intuition was self-grounded; that is, it was productive of knowledge even though it was not derived from any other source. "By 'intuition' I do not mean the fluctuating testimony of the senses or the deceptive judgment of the imagination as it botches things together."[44] Intuition was defined as an immediate grasp of connectivity between ideas—here the example is noticing that a sphere is bounded by a single surface, revealing how the mind can "see" the connection between the experience of the sphere's shape and the extent of its surface features. The common sense synthesizes those experiences, yet it cannot remark the certain *relationship* between these experiences. The model of thinking that emerges in this text is one structured in terms of

the grasping and regrasping of relations and proportions as they appear within the experiences generated by the physiological systems of sensation. The soul represented a spark of "the divine" within the corporeal system, another way of describing the unprecedented action that disrupts the regular economy of the information system.

But significantly, Descartes would sometimes describe corporeal cognition in analogous terms. In the famous Rule 12 of the *Regulae*, for example, Descartes shows how sensory impressions function as information, in that they represent specific characteristics of the external world via coded signs. In essence, the body "intuits" certain features and relationships and transmits these internally in semiotic formations.[45] Even earlier, in a short treatise on music presented to his friend and mentor Isaac Beeckman, Descartes had been speculating about the *sensory* grasp of proportionality and unitary structures in the nervous system.[46] The imagination, for Descartes a purely corporeal faculty, is, as Dennis Sepper has written, "an extraordinarily active power that is responsible for the ability to perceive the complex unity of sounds as a whole."[47] Even the senses themselves, as Descartes described them here, grasp qualities latent within reality and configure these semiotically. These representations are themselves reconfigured by various new transformations—for example, in the instantaneous transmission of sensory impressions to the "common sense" in the brain, which imprints a synthetic reordering of these relationships on the imagination or in the memory. In a series of almost anamorphic transformations, the Cartesian body is always at work grasping, relating, unifying.[48]

The ambiguity of the distinction between corporeal cognitive activity and that of the pure intellect is most apparent in Descartes's *La Dioptrique* (*Optics*). Once again emphasizing the nonrepresentational nature of sensory information, Descartes imagines a blind man feeling his way with a stick as an analog of the body's own method of gaining knowledge of the external world. He "receives" the relevant information from his environment (shapes, size, and so on) from the positioning of the stick, the prosthetic instrument that mediates the translation from physical movement to *information*. "One might almost say that they see with their hands, or that their stick is the organ of some sixth sense." The point Descartes wants to make here is that light is exactly just such a "rapid movement" that physically impinges on the sense organ of the eye, giving information to the brain that enables the perception by the soul of certain qualities in nature.

Yet, remarkably, the senses also enable a kind of automated form of reasoning that gives the body a sense of spatial relations and distance. Since the world is not given by the senses, it must be organized, perhaps processed is a better word, in order to reveal the true position of the body within the external world. As Descartes says, not only do the different views from our

binocular visual system get integrated in the brain, it is also the case that when we adjust our eyes to the varying "distances" of objects that come into our experience, "we change a certain part of the brain in a manner that is ordained by nature to make our soul perceive this distance."[49] The proprioceptive representation is founded on a fairly complex mode of calculation, since the absolute size and shape of objects cannot indicate their "real" positioning in the external world. The nervous system and brain must triangulate, so to speak, all the information available on the positioning of the body and its immediate space to know immediately that a particular object (say a square tower in the distance) is not misinterpreted (as a small circular object in the immediate vicinity). Here, and in other texts, Descartes seems to attribute a form of reasoning to the nervous system, even as he claims elsewhere, we know, that such reasoning is the exclusive domain of the soul.[50] One thing is clear, I would suggest: there is not any radical *qualitative difference* here between corporeal intuitions and their rational organization into meaningful relations, and intellectual intuitions leading to systematic chains of inference, as described in the *Regulae*.

So what distinguishes the intervention of the soul from the information processing and memory storage/retrieval that marks the ongoing activity of the nervous system? In a late letter to Antoine Arnauld, Descartes gives us an important clue with respect to the function of memory at least. He remarks that if memory is to function as memory—as a genuine disruption of the corporeal economy that is—it must have some way of distinguishing itself from the impressions and coded patterns that continually flow through the machine. As Descartes explains, the mind must be able to recognize (the word used is *agnoscamus*) memory as *repetition* if it is going to stimulate new comparative thinking and initiate novel forms of behavior. Therefore, these past experiences must somehow be marked as having already taken place. "Now for the mind to recognize this, I think that when these traces were first made it must have made use of pure intellect to notice that the thing which was then presented to it was new." Descartes claims that there can be no "corporeal trace" (*corporeum vestigium*) of this remarking of novelty: only pure intellect is capable of a complete escape from experience, taking it as an object of its own experience and thus marking and remarking it temporally and structurally within the cognitive complex of sensation, memory, and intuition or judgment.[51] The implication here is that because it can "see" novelty, the pure intellect is itself *capable* of novelty—both are the consequences of a radical reflexivity. This is why children (and maybe some adults) do not really think, Descartes comments, until the intellect has the strength to free itself from its own bodily experience and automatic mental habits, which are akin to the learning mechanisms of bodily reflex—for example, the dog learning to flee at the sound of the violin.

Here Descartes begins to give an explanation of why humans alone are capable of producing speech, the telltale mark that will reveal the difference between true human and complex automaton. The association between the word and the idea is completely arbitrary, Descartes asserts, and therefore there is no way that this connection could be traced in the physiological system of brain passages and nervous conduits of animal spirits—there must be a purely *intellectual* connection made (and subsequently preserved) by the soul alone.[52] And yet, in *Le monde* and in the *Optics*, Descartes repeatedly draws attention to the fact that the informational sign of the body works analogously to the signs of convention that are linguistic.

> Now, if words, which signify nothing except by human convention, suffice to cause us to conceive of things to which they bear no resemblance, why could not nature also have established a certain sign that would cause us to have the sensation of light, even though that sign itself bore no similarity to that sensation?[53]

Again, in the *Optics* he says, "Is it not thus that nature has established laughter and tears, to make us read joy and sadness on the faces of men?" Descartes often implied that these relations were in a sense "hard wired" into the physiological organization of the brain. Yet one may also think of the "arbitrary" sign that is the *learned* connection between violin and violence for the dog. For the signs of language (and culture) are established, as Descartes well knows, according to the social world one inhabits. As he remarks in the *Discours*: "I thought too, how the same man, with the same mind, if brought up from infancy among the French or Germans, develops otherwise that he would if he had always lived among the Chinese or cannibals."[54] This cultural determination is predicated less on the action of the soul, it seems to me, than on the open and plastic structure of the brain—"the substance of the brain being soft and pliant," it can take on habits based on connections that are *not* made by the mind but by external agents or circumstances.[55] Language and custom are forms of cultural training, analogous to the automatic accumulations of memory derived from experience of the natural world. Words function as tools of meaningful communication, Descartes said in the *Passions de l'âme* (*Passions of the Soul*), "because we have acquired the habit of thinking of this meaning when we hear them spoken or see them written."[56] The question remains: how can we best locate the essential functions and characteristics of the pure intellect?

From this perspective, the *Meditations* can be read as a demonstration of just how *difficult* it is to isolate pure thinking within a complex cognitive realm dominated by corporeal forms of mental organization and reorganization. "My habitual opinions keep coming back, and, despite my wishes, they capture my belief, which is as it were bound over to them as a result of long occupation and the law of custom."[57] In the famous passages from the

Second Meditation, Descartes first locates pure intellection in the act of judgment—it is, he explains, the ability to see something that is *not at all present* in our sensory information, an echo of what he called "intuition" in the *Regulae.* We might see, touch, even hear the innumerable changes in, for example, a piece of malleable wax, we can even imagine (in the corporeal sense of that word) changes that have not taken place yet—new shapes for example. However, only the intellect can "see" wax itself—that invisible form of identity that persists throughout these changes.[58] The pliant wax—like the pliant brain—can take on many forms, but only the intellect can perceive the underlying identity that is itself not accessible to sensory perception, for it can literally make no impression on the nervous system. The intellectual judgment is no doubt parasitic on the corporeal cognition generated by sensation and its processing in the common sense but it is not, Descartes demonstrates here, identical with it.[59] "Therefore this insight [*comprehensio*] is not achieved by the faculty of the imagination." The perception of the identity is an "inspection of the mind alone [*solius mentis inspectio*]."[60]

But what does the intellect see? What is the *foundation* of this judgment? It is not clear that the unity of these transformations can be intuited from the independent status of each phase of transformation. The judgment appears to be an artificial synthesis of the corporeal experiences. Descartes gives us another, brief (but revealing) example of this intellectual ability to judge beyond perception. He writes:

> But then if I look out my window and see men crossing the square, as I just happen to have done, I normally say I see the men themselves, just as I say I see the wax. Yet do I see any more than hats and coats which could conceal automata? I *judge* that they are men. And so something which I thought I was seeing with my eyes is in fact grasped solely by the faculty of judgment which is in my mind.[61]

The question we can ask is, why should we judge them to be men? The judgment may well be in error, for in order to recognize these figures as genuine humans, and not the machines they appear to be, we would need to perceive the signs of "pure intellect" itself, this strange capacity to see what is not really there. My suggestion is that this *lack* is what defines the threshold of the human for Descartes. The difference between the robot and the human is not attributable to any substantial content of the soul's being, something new that is "added" to the robotic organization. Rather, the soul *intervenes*—it is the cut into the system that opens up a new form of action, rather than an intervention *of* some particular kind. The intervention is, in other words, an "interruption" in the radical sense of the word. The soul does not construct unity so much as interfere with the automatic integrations of sensory information that are the product of a constant making and remaking of order that takes place in the brain.

Descartes returned to the nature of this peculiar relationship between the soul's activity and the automaticity of the robotic body in his last published work, the *Passions de l'âme*, which opens with a careful discussion of the status of the mind/body intersection. The key trope is unity—Descartes is concerned with the question of the extent to which the body constitutes a self-enclosed unity, but also ponders the nature of the strange unity that *unites* intellect and body in the figure of the human, without substantially reducing the operations of the intellect to the functions of the nervous system. In this text, it is the operation of the passions that will be studied closely, for the passions constitute the essential connection between the experiential functions of the sensing body and the purely intellectual functions of the soul. Again, Descartes is interested in this liminal space of connection that unites while keeping apart the nervous system and the intellect.

The first point to make is that the body's internal economy (its organization, motion, and "life") is not at all dependent on the soul for its unity: "Death never occurs through the absence of the soul, but only because one of the principal parts of the body decays."[62] Life and death is the distinction between functioning and damaged physiological systems—both health and pathology are the consequence of the machine's own internal laws.[63] After a brief overview of his theory of the gross anatomy and physiology of the body, Descartes proceeds to explain the special function of the nervous system in some detail, repeating the ideas developed in the *Traité de l'homme*, but with a new inflection. He emphasizes here, first, the absolute integrity of the animal or human body mechanism. Every movement that is not willed "occurs in the same way as the movement of a watch is produced merely by the strength of its spring and the configuration of its wheels."[64] The soul is here excluded from the logic of the body's own operations. But the soul inhabits this space in a special way: "The various perceptions or modes of knowledge present in us may be called its passions . . . for it is often not our soul which makes them such as they are, and the soul always receives them from the things that are represented by them."[65] And as we know, the soul can also, according to Descartes, initiate "actions that terminate in our body"—that is, the soul can *will*. This special relationship is important, precisely in its strangeness. Elsewhere, Descartes would claim that if an angelic intelligence were to inhabit the bodily space, position itself, as it were, in the pineal gland, "it would not sense the world as we do." Instead, the angel would simply observe "the motions which are caused by external objects," as they pass through the animal spirits; it would perceive, that is, only the raw "coding" of the information flowing through the nervous system. The angel spliced into a human automaton thus "would differ from a real man."[66] Our souls are so deeply intertwined with our bodies that we

actually *feel* the sensory information as subjective experience. As he says repeatedly in the *Passions*, these relations are "ordained by nature."

The *Passions* is in one important sense an attempt to understand the function of this intimately bound soul, to understand it, that is, from the perspective of the corporeal economy. The passions are, in effect, a supplement to memory, which was already staged as a supplement to sensory information and a preliminary form of disruption within the linear sequence of sensation, action, and reaction. The passions, as opposed to memory, operate as a kind of warning system for the body.[67] Pain, joy, sadness, courage, and such, all are ways the body presents challenges or opportunities to itself, based on its needs, its existential condition. While a certain form of homeostasis is explicable, according to Descartes, by the mechanisms of reflex and the aid of repeated past experience, the passions that are felt by the soul signal the demands of various organismic systems within the body as a whole. The soul is engaged with this corporeal unity and functions, Descartes will suggest, as a space for decision. When passion "impels us to actions which require an immediate decision [*résolution*], the will must devote itself mainly to considering and following reasons which are opposed to those presented by the passions, even if they appear less strong." The example is an "unexpected attack of the enemy" when there is "no time for deliberation."[68] But still, there is time for decision, which interrupts the automaticity of the fear response, or the strong desire for honor. The soul can turn *against* these responses by attending to their opposites.

And so Descartes is careful not to incorporate, completely, the logic of the intellect into the organizational order of the body. The body is already, he says, a "unity which is in a sense indivisible because of the arrangement of its organs, these being so related to one another that the removal of any one of them renders the whole body defective."[69] Similarly, the soul has its own indivisibility, its own form of foundational unity. In this text Descartes is suggesting that the point of contact between soul and body is negotiated precisely at the intersection of these two *unities*. The soul is joined to the whole body, the body's wholeness more specifically, and the physiological space where that unity is best expressed is the brain's own center, the pineal gland. That gland, as we saw, was automatically inscribed by the informational systems of the body simultaneous to their occurrence. The pineal gland, in other words, is where the body's diverse systems are "represented" as a unified being, via the common sense and the activity of the brain's own organizational capacity. Not surprisingly then, the soul "exercises its functions" in relation to the body "more particularly" in the pineal gland than anywhere else. I rely here on Nima Bassiri's innovative reading of this fundamental point: "the pineal gland," he claims, "is *organizationally* reduplicating the body's sensory affections."[70]

As some scholars are now asserting, Descartes is presenting in the *Passions* a tentative but powerfully novel conception of the human as a "single system" consisting of both physiological organization *and* the functions of intellectual intervention.[71] I would modify this perceptive claim in one significant way: I think Descartes is setting the stage for the idea that the soul (whatever its own aspirations) is the entity that takes responsibility for acting on behalf of the body's own integral unity in the absence of any clear existential reaction. The human body is not without its own order and organization; it runs automatically and, like the animals, would surely persist for the most part in its "natural" condition. But in moments of crisis, the virtual integration of the body's diversity in the brain does not itself constitute an *effective* representation of its own unity.

It is important to recognize, however, that for Descartes the soul can never function as a rational "sovereign" figure of totalized control, since that would violate both the integrity of the body's own systems *and* misrepresent the activity of the soul. As Descartes wrote in the *Meditations*, the soul is not at all like the pilot of the ship, who controls the vessel as if it were an organ—that is, as a mere external instrument of its own desire, an *organon*. Like the leaders of cybernetics, the discipline which took its name from the Greek notion of "steering," from the word *kyber*, Descartes here insisted on seeing the organism as a functional whole, an integration of intellectual and bodily systems, of informational and material operations. That is, the human body is a complex unity that steers itself; it is an automaton. But it is an automaton of a wholly new order. Only in the human body does the organism *as a whole* have its own representative system, that is, a soul, itself perfectly integrated in its unity and capable of acting without experiential precedent.

In the *Passions*, Descartes redescribes the soul's function in relation to the existential demands of the body. The passion of "anxiety," for example, is raised in the soul when something "very strange and terrifying" is perceived. While one can imagine an animal fleeing automatically from this danger, the point that Descartes emphasizes is that the soul can make a decision, one that is not at all predetermined by the nature of the bodily response. The soul is co-opted by the body to serve its essential existential drive: "the principle effect of all the human passions is that they move and dispose the soul to want the things for which they prepare the body."[72] All the same, the actual discussion of the fight or flight response in this passage relies exclusively on the automatic movement of the animal spirits through the information systems of the body and back to the muscles, which will explain the ultimate action taken.[73] What is perhaps more important is Descartes claim that the "strength of the soul" consists in the ability to *resist* the passions, which is to say, from the body's perspective, the function of the

soul is to interrupt or displace the automatic mechanisms of the automaton. "For undoubtedly the strongest souls belong to those in whom the will by nature can most easily conquer the passions and stop the bodily movements which accompany them."[74] And although Descartes cannot help but admit that even dogs can be trained to act counter to their nature, despite their lack of thought and reason, by changing "the movements of the brain," he positions the soul as the being that is capable of redirecting or inflecting or resisting the automatic flow of response within the automaton according to a decision, and not a mere habit. And with this purpose in mind: the passions are excited in us by objects in the world "because of the various ways in which they may harm or benefit us."[75] The soul is affected by the passions, in that it now desires what the body already "desires" and thus may persist in a course of action despite the changing physiological conditions of the body or the environment, or, perhaps, the presence of *conflicting* impulsions. But this understanding of the passions does not, in the end, do more than inscribe the soul within the organization of the body, amplifying its operation for sure, but hardly offering a radically novel form of action. We can say that here the passions function analogously to memory.

The key moment in the text is when Descartes points out a certain special kind of passion that is not like all the others, in that it is an exception to the very logic of desire and fear that shapes the movements in the brain and produces the basic passions Descartes has enumerated. The singular passion of wonder, he explains, is unusual precisely because it has no relation at all to the immediate well being of the body. This passion affects only the *brain*, he explains. Yet the Cartesian brain is a system that continually reflects and organizes the body's own operation, so in its very openness it can hardly have its own object of desire. What exactly is wonder? The "sudden surprise of the soul which brings it to consider with attention the objects that seem to it unusual and extraordinary."[76] Wonder is therefore a radical *disruption* of the body's working, and not an amplification or adjudication. The body itself alerts the soul to the presence of something fundamentally *unknown* with this passion. Now, it is exactly *this* state which is impossible in the animal robot, for it can react to something only if it can be understood in relation to its immediate needs, or with respect to its memory. The shock of the new within the animal machine cannot produce behavior.

So how does the machinic body go beyond itself to alert the soul to something *unknown*? Wonder is, Descartes tells us, an "impression of the brain, which represents the object as something unusual and worthy of special consideration."[77] The challenge is to explain how a material system can express its own absence of information—the quality of the unusual. As Descartes will suggest, the novelty of the impression is marked by the fact that certain parts of the pliant brain that have not normally been affected in

the past have been suddenly forced into new configurations. At this moment, the animal spirits flow to both this site of novelty and to the sense organs, so that they remain fixed on the new object, so that the soul will be forced, in a sense, to acknowledge it. Whatever the physiological explanation, the functional point is absolutely clear: wonder is the way that a body interrupts itself in the face of a novel and unprecedented situation, in order that the soul might initiate a response that no longer aims to duplicate an anticipated bodily response but activate one that is wholly new to the body. Other passions (and the analogous motions of the spirits in animals) are defined by their identification of "good" and "evil." Only wonder is a passion defined solely by the state of surprise, the purest form of interruption. What makes this interruption productive is the fact that the soul is forced to attend to the new and retain it in the memory for future contemplation. (If animals are surprised, and Descartes is silent on this issue, it would serve only to redirect the animal momentarily, until an automatic response is activated.) The main point I will make here is that wonder, unlike the other passions, is agnostic because its object is defined as the unknown, as absence. Therefore wonder always provokes a genuine decision, while preparing the ground for new knowledge; that is, only if the soul rises to the challenge and is not absorbed completely to the point of immobility, the pathological state of "astonishment."[78]

Thomas Hobbes would of course insist, in opposition to Descartes, that only the passions themselves impel the body to maintain itself, and that the will is just a name for the outcome of a battle of passionate intensity: fear of death, for example, may simply outweigh hunger or thirst or love at any one moment. For Descartes, however, the passions were linked to the soul by virtue of its special relationship with the body. This is why the body has a feeling soul (we can leave aside the question as to why a soul has a body). Animal machines—and even human machines for the most part—can operate without the soul because the mechanisms of information flow, organization, and response keep the organism alive without any interruption. The human soul, however, can *intervene* to sustain or resist these operations for the good of the organism, or even, with wonder, to *interrupt* entirely the automatic functioning of the specific systems on behalf of the existence of the united body, but also with the further goal of acquiring new knowledge in mind. A genuinely autonomous robot must therefore itself be somewhat "autonomous" of its own systems if it is going to display the flexibility and adaptability of the human being.[79]

In this way Descartes reflects a fundamental tension at the origin of a modern scientific view of human cognition. The models of mechanical thinking, however sophisticated they may have become in our own epoch, demand a reductionist approach to the cognitive activities that define us as

human. At the same time, the machinic model, as Georges Canguilhem has suggested, cannot account for the organizational unity of the vital living being. In the *Passions*, Descartes goes beyond the simple machine system by conceptualizing the unity of the organism in a dynamic sense. The automaton that is the higher animal is equipped with an open, plastic information and memory system that literally reorganizes itself according to its individual experience and "social" training. It is an open system. The human automaton, importantly, is not just capable of reorganizing itself; it is also endowed with a capacity for *self-interruption*. The soul intervenes on behalf of the life of the organism, by forcing the automaton to act against its own automaticity. However slight the impact of the soul might be in the face of the passions, this is the zone where the soul realigns the organization altogether, beyond the logic of its own automaticity. The human is, therefore, no simple addition to the living mechanized body, a reasoning being trapped in a material existence, an awkward marriage in both philosophical and practical terms. The human as a Cartesian robot is a hybrid, defined by its material organization, yet open to both cultural and technical formation—and often inspired to use that very capacity for openness to remake itself freely in moments of true decision. This hybrid entity is an ethical being.

Cartesian robotics suggest that we interrogate the history of modern thinking and the history of cognitive theory that was opened up in the seventeenth century as an ongoing, complex intersection of evolving conceptions concerning minds, vital bodies, and material technologies. Instead of seeing the history of cognition as a story of advancing neurobiological reduction, we should seek out those moments that resist coherent, materialist explanations of the *l'homme-machine*, that is, moments when machines and humans (and animals) all evoked genuine questions about openness, creativity, and indetermination.

Notes

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The following abbreviations will be used for Descartes's works:

AT = *Oeuvres de Descartes*, ed. Charles Adam and Paul Tannery, 11 vols. (Paris, 1983)

CSM = *The Philosophical Writings of Descartes*, 3 vols., trans. John Cottingham, Robert Stoothoff, and Dugald Murdoch (volume 3 including Anthony Kenny) (Cambridge, 1988).

1. Antonio Damasio, *Descartes' Error: Emotion, Reason, and the Human Brain* (New York, 1994), 249.
2. Bernard Stiegler, *Technics and Time*, vol. 2, *Disorientation* (1996), trans. Stephen Barker (Stanford, 2009), 164. Cf. Paul Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America* (Cambridge, MA, 1996), esp. chaps. 6–8.
3. Olivier Houdé, "L'esprit, le cerveau et le corps: Descartes face aux sciences cognitives," in Annie Bitbol-Hespériès et al., *Descartes et son oeuvre aujourd'hui* (Sprimont, Belgium, 1998).
4. For an overview of this theory, see the excellent essays on perception and thinking collected in Stephen Gaukroger, John Schuster, and John Sutton, eds., *Descartes' Natural Philosophy* (London, 2000). Other recent works emphasizing Descartes's physiological approach to cognition include Daniel Garber, *Descartes Embodied: Reading Cartesian Philosophy Through Cartesian Science* (Cambridge, 2001); Dennis des Chene, *Spirits and Clocks: Machine and Organism in Descartes* (Ithaca, NY, 2001); Stephen Gaukroger, *Descartes: An Intellectual Biography* (Oxford, 1995); Dennis Sepper, *Descartes's Imagination: Proportion, Images, and the Activity of Thinking* (Berkeley, 1996); John Sutton, *Philosophy and Memory Traces: Descartes to Connectionism* (Cambridge, 1998).

   On the medical philosophy, see Vincent Aucante, *La philosophie médicale de Descartes* (Paris, 2006), and Richard B. Carter, *Descartes' Medical Philosophy: The Organic Solution to the Mind-Body Problem* (Baltimore, 1983).
5. Descartes to Marin Mersenne, 1632, AT 1:263; CSM 3:40.
6. Norbert Wiener, *Cybernetics, or Control and Communication in the Animal and Machine* (Cambridge, MA, 1948), 40.
7. C. E. Shannon and J. McCarthy, eds., *Automata Studies* (Princeton, 1956), preface: "Among the most challenging scientific questions of our time are the corresponding analytic and synthetic problems: How does the brain function? Can we design a machine which will simulate a brain? Speculation on these problems, which can be traced back many centuries, usually reflects in any period the characteristics of machines then in use. Descartes, in *De Homine*, sees the lower animals and, in most of his functions, man as automata. Using analogies drawn from water-clocks, fountains, and mechanical devices common to the seventeenth century, he imagined that the nerves transmitted signals by tiny mechanical motions. Early in the present century, when the automatic telephone system was introduced, the nervous system was often likened to a vast telephone exchange with automatic switching equipment directing the flow of sensory and motor data. Currently it is fashionable to compare the brain with large scale electronic computing machines. . . . The development of large scale computers has led to a clearer understanding of the theory and design of information processing devices."
8. Arturo Rosenblueth, Norbert Wiener, and Julian Bigelow, "Behavior, Purpose, and Teleology," *Philosophy of Science* 10 (1953): 18–24.
9. See Anatol Rapoport, "Technological Models of the Nervous System" (1955), in *The Modeling of Mind: Computers and Intelligence*, ed. Kenneth M. Sayre and Frederick J. Crosson (New York, 1963), 32.
10. Warren McCulloch and John Pfeiffer, "Of Digital Computers Called Brains," *Scientific Monthly* 69 (1949): 368–76.

11. Bernard Stiegler, *Time and Technics*, vol. 1, *The Fault of Epimetheus* (1994), trans. Richard Beardsworth and George Collins (Stanford, 1998), 175.
12. On the importance of this idea of information in Descartes's work, see Jacques Bouveresse, "La mécanique, la physiologie et l'âme," in Bitbol-Hespériès et al., *Descartes et son oeuvre aujourd'hui*, 99–100; Jean-Luc Marion, *Sur l'ontologie grise de Descartes: Science cartésienne et savoir aristotelicien dans les "Regulae"* (Paris, 1981), 119, 123–25; editors' introduction to Gaukroger, Schuster, and Sutton, *Descartes' Natural Philosophy*, 16; Amélie Oksenberg Rorty, "Descartes on Thinking with the Body," in *Cambridge Companion to Descartes*, ed. John Cottingham (Cambridge, 1992), 378.
13. On Descartes's conceptual move and its context, see Des Chene, *Spirits and Clocks*, chap. 6, and Gary Hatfield, "Mechanizing the Sensitive Soul," in Gideon Manning, ed., *Matter and Form in Early Modern Science and Philosophy* (Leiden, 2012), 151–86.
14. In general, see Otto Mayr, *Authority, Liberty, and Automatic Machinery in Early Modern Europe* (Baltimore, 1986); for religious automata see Jörg Jochen Berns, "Sakralautomaten. Automatisierungstendenzen in der mittelalterlichen und frühneuzeitlichen Frömmigkeitskulture," in Klaus Grubmüller and Markus Stock, eds., *Automaten in Kunst und Literatur des Mittelalters und der Frühen Neuzeit* (Wiesbaden, 2003), 197–222, and Jessica Riskin, "Machines in the Garden," *Republic of Letters: A Journal for the Study of Knowledge, Politics, and the Arts* 1, no. 2 (2010): 16–43, available at: http://rofl.stanford.edu/node/59.
15. Descartes to Reneri [Henri Regnier] for Alphonse Pollot, April or May 1638, AT 2:39–40; CSM 3:99.
16. Descartes to Henry More, February 5, 1649, AT 5:277–78; CSM 3:366.
17. Ibid.
18. Descartes, *Discours de la méthode*, AT 6:56–57, CSM 1:140.
19. John Cottingham, "Cartesian Trialism," *Mind* 94 (1985): 218–30. Cf. Fernando Vidal, *The Sciences of the Soul: The Early Modern Origins of Psychology*, trans. Saskia Brown (Chicago, 2011), 77.
20. "Now I shall not pause to describe to you the bones, nerves, muscles, veins, arteries, stomach, liver, spleen, heart, brain, nor all the other different pieces of which the machines must be composed; for I suppose them all to be quite like the parts of our own body that have the same names"; Descartes, *Traité de l'homme*, AT 11:120, CSM 1:99.
21. Descartes, *Principia Philosophicae*, AT 9b:326; CSM 1:289.
22. Gary Hatfield, "Descartes' Physiology and Psychology," *Cambridge Companion*, 341.
23. Annie Bitbol-Hespériès, *Le principe de vie chez Descartes* (Paris, 1990); Stanley Finger, *Minds Behind the Brains: A History of the Pioneers and Their Discoveries* (Oxford, 2000).
24. On Galen see F. R. Freeman, "Galen's Ideas on Neurological Function," *Journal of the History of Neuroscience* 3 (1992): 263–71.
25. On the transformation of "psychology" in the seventeenth century, from science of the soul as "animating principle of all living beings" to the study of "the rational human soul united with the body," see Vidal, *Sciences of the Soul*, 57. For the importance of the unity of mind and body in Descartes's physiology, see Annie Bitbol-Hespériès, introduction to Descartes, *Le Monde, L'homme* (Paris, 1996).
26. As Georges Canguilhem has forcefully argued, Descartes's mechanical understanding of the bodily organism merely displaces the Aristotelian question of the

soul as form, and the telos of the formal organization, onto the figure of the Creator—whether it is divine or human in nature: "Mechanism can explain everything so long as we take machines as already granted, but it cannot account for the construction of machines." See Canguilhem, "Machine and Organism" (1948), in Canguilhem, *Knowledge of Life*, ed. Paola Marati and Todd Meyers, trans. Stefanos Geroulanos and Daniela Ginsburg (New York, 2008), 87. I will return to the question of the unity of organism and machine in the discussion of Descartes's later work, the *Passions de l'âme*.

27. Descartes, *Traité de l'homme*, AT 11:131; CSM 1:100–101.
28. "And note by 'figures' I mean not only things that somehow represent the position of the edges and surfaces of objects, but also everything which, as indicated above, can cause the soul to sense movement, size, distance, colors, sounds, odors, and other such qualities; and even things that can make it sense titillation, pain, hunger, thirst, joy, sadness, and other such passions"; ibid., 85.
29. Paul Miers, "Descartes and the Algebra of the Soul," *MLN* 110 (1995): 948.
30. Jean-Pierre Séris, "Language and Machine in the Philosophy of Descartes," in *Essays on the Philosophy and Science of René Descartes*, ed. Stephen Voss (New York, 1993), 183.
31. Descartes's theory of the pineal gland is often misunderstood. First, he was not the first to conjecture the cognitive function of the gland. Its peculiarity gave rise to various speculations, and Descartes was relying heavily on prior anatomical work on the brain as well as his own animal dissections. Second, Descartes did not believe that only human brains had pineal glands—it was common knowledge that it existed in animals and Descartes himself often referred to them. See Bitbol-Hespériès, *Le principe de vie* as well as Aucante, *La philosophie médicale*.
32. On the complex ontological status of the pineal gland in relation to both soul and body, see Nima Bassiri, "Material Translations in the Cartesian Brain," *Studies in History and Philosophy of Biological and Biomedical Sciences* 43 (2012): 244–45.
33. Descartes, *Meditationes (Objectiones Quartae)*, AT 7:229–30; CSM 2:161.
34. "Psycho-physics, by granting sensations their own law of formation, introduces into nature the reality of information that is irreducible to the principle of the equality of cause and effect, proper to Cartesian mechanism"; Jules Vuillemin, *Mathématique et métaphysique chez Descartes* (Paris, 1960), 34.
35. Descartes, *Principes de la philosophie*, AT 8a:320; CSM 1:283.
36. Ibid., AT 8a:321; CSM 1:284.
37. On the complexity of memory in Descartes see Sutton, *Philosophy and Memory Traces*, part 1.
38. Descartes to Mersenne, March 18, 1630, AT 1:134; CSM 3:20.
39. On this process see John Morris, "Pattern Recognition in Descartes' Automata," *Isis* 60 (1969): 451–60.
40. Descartes, *Traité de l'homme*, AT 11:185. This passage is omitted in the translation in CSM.
41. It is worth noting that Aristotle himself preserved the explanatory power of causation in the higher animals with a similar argument—experience could be maintained in the body and therefore cause behaviors at a later moment. See Klaus Corcilius, *Streben und Bewegen. Aristoteles' Theorie der animalischen Ortsbewegung. Quellen und Studien zur Philosophie*, vol. 79 (Berlin, 2008).
42. Descartes, *Traité de l'homme*, AT 11:132; CSM 1:101.
43. On this aspect of the *Regulae* see Stephen Gaukroger, *Cartesian Logic: An Essay on Descartes's Conception of Inference* (Oxford, 1989), 25, 127–28; and Marion, *Sur l'ontologie grise*, 30.

44. Descartes, *Regulae ad Directionem Ingenii*, AT 10:368; CSM 1:14.
45. "Take color, for example: whatever you may suppose color to be, you will not deny that it is extended and consequently has shape. So what troublesome consequences could there be if—while avoiding the useless assumption and pointless invention of some new entity, and without denying what others have preferred to think on the subject—we simply make an abstraction, setting aside every feature of color apart from its possessing the character of shape, and conceive of the difference between white, blue, red, etc. as being like the difference between the following figures or similar ones? . . . The same can be said about everything perceivable by the senses, since it is certain that the infinite multiplicity of figures is sufficient for the expression of all the differences in perceptible things"; Descartes, *Regulae*, Rule 12, AT 10:413; CSM 1:40–41.
46. Descartes, *Abrégé de musique (compendium musicae)*, trans. F. de Buzon (Paris, 1987).
47. Sepper, *Descartes's Imagination*, 45.
48. See Betsy Newell Decyk, "Cartesian Imagination and Perspectival Art," in Gaukroger, Schuster, and Sutton, *Descartes' Natural Philosophy*, for a discussion of anamorphic art and its relationship with Descartes's ideas on corporeal cognition.
49. Descartes, *La Dioptrique*, AT 6:137; CSM 1:170.
50. See Deborah J. Brown, *Descartes and the Passionate Mind* (Cambridge, 2006), 60–70, for a systematic analysis of this ambiguity surrounding "reason" in Descartes's theory of the nervous system and his account of the intellectual mind.
51. Descartes to Antoine Arnauld, July 29, 1648, AT 5:220; CSM 3:356.
52. Descartes, Conversation with Frans Burman, April 16, 1648, AT 5:150; CSM 3: 336–37.
53. Descartes, *La Dioptrique*, AT 4:87; CSM 1:3.
54. Descartes, *Discours*, AT 6:16; CSM 1:119.
55. Descartes, *Traité de l'homme*, AT 11:173; CSM 1:104.
56. Descartes, *Passions de l'âme*, §50, AT 11:369; CSM 1:348.
57. Descartes, *Meditationes de Prima Philosophiae*, AT 7:22; CSM 2:15.
58. Ibid., AT 7:31–32; CSM 2:20–21.
59. As Dennis Sepper explains, "There can be no thinking and knowing without the internal senses and their phantasms. All reasoning, conceiving, understanding, all science and truth, must come to us by way of and accompanied by phantasms." Sepper, *Descartes's Imagination*, 28.
60. Descartes, *Meditationes*, AT 7:31; CSM 2:21.
61. Ibid.
62. Descartes, *Passions*, §6, AT 11:330; CSM 1:329.
63. Descartes, Conversation with Burman, AT 5:163–64; CSM 3:346 and ibid., AT 5: 179; CSM 3:354: "Even when we are ill, nature still remains the same." On Descartes's thinking on pathology see Aucante, *La philosophie médicale*, chap. 8.
64. Descartes, Conversation with Burman, §16, AT 11:342; CSM 1:335.
65. Ibid., §17, AT 11:342; CSM 1:335.
66. Descartes to Regius [Henri le Roy], January 1642, AT 3:493; CSM 3:206.
67. See Carter, *Descartes' Medical Philosophy*, 119–20, for a similar formulation.
68. Descartes, *Passions*, §211, AT 11:487; CSM 1:403–4.
69. Ibid., §30, AT 11:351; CSM 1:339.
70. Bassiri, "Material Translations," 249.
71. Brown, *Descartes and the Passionate Mind*, 141.
72. Descartes, *Passions*, §40, AT 11:359; CSM 1:343.

73. Ibid., §36, AT 11:356; CSM 1:342.
74. Ibid., §48, AT 11:367; CSM 1:347.
75. Ibid., §52, AT 11:372; CSM 1:349.
76. Ibid., §70, AT 11:380; CSM 1:353.
77. Ibid.
78. Ibid., §73, AT 11:382–83; CSM 1:354.
79. Recently, Christof Koch has framed this problem in ways that look back to Descartes's seminal effort to think the human from within the cybernetic automaton. As he writes, most actions of the higher animals depend on "zombie agents" that are automatically executed. "The hallmarks of a zombie system are stereotypical, limited sensorimotor behaviour, and immediate, rapid action. Its existence raises two questions. First, why aren't we just big bundles of unconscious zombie agents? Why bother with consciousness, which takes hundreds of milliseconds to set in?" For Koch, human thinking reveals best how nature has "evolved a powerful and flexible system whose primary responsibility is to deal with the unexpected and to plan for the future." "The function of consciousness . . . is to handle those special situations for which no automatic procedures are available." See Christof Koch and Francis Crick, *The Quest for Consciousness: A Neurobiological Approach* (Englewood, CO, 2004), 318–19.