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# Merleau-Ponty on Embodied Cognition: A Phenomenological Interpretation of Spinal Cord Epidural Stimulation and Paralysis

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## Abstract

In a study in *Brain* (2014), Dr. Susan Harkema and her fellow researchers demonstrated that the input of an electronic epidural stimulator in the lower spinal cord of four completely paralyzed patients allowed them to regain *voluntary* movement in their toes, defying the longstanding scientific position regarding sensory and motor complete paralysis. Harkema herself admits that she thought this achievement was impossible at the outset, as she believed that the body is incapable of movement without receiving complex signals from the brain. Many cognitive neuroscientists continue to maintain this standpoint of Cartesian dualism. In response, I argue that the insights of Maurice Merleau-Ponty provide a possible explanation of the results of this new research. Merleau-Ponty insisted that I *am* my body and that the body has its own kind of knowledge about the world. This framework serves as the backdrop for recent phenomenological studies in cognitive neuroscience. In this vein, this essay will consider how Merleau-Ponty's account of embodiment provides an ample model for explaining the findings of Susan Harkema's current spinal cord research.

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## INTRODUCTION

Lumbosacral spinal cord epidural stimulation is considered to be one of the most significant medical breakthroughs in paralysis research. Since the initial research began in 2011, it has allowed four paralyzed men to regain their ability to move their lower limbs and have a higher quality of life. The process involves a small electrical device roughly the size of a pacemaker, which is surgically implanted in the paralyzed patient and is attached to the lower section of the spinal cord in 16 different locations. Thus far, the implantation of the device has been used in four men whose spinal cord injuries rendered them paralyzed from the chest down for life—two of which were clinically diagnosed with both sensory and motor complete paralysis and two of which had motor complete but sensory incomplete paralysis. As a result of the stimulator and extensive therapy, all four participants have regained the capacity to voluntarily move their legs and have even been able “to achieve full weight-bearing standing without any external assistance and with only minimal self-balance assistance provided by their hands when the lumbosacral spinal cord was epidurally stimulated.”<sup>i</sup> In other words, the four men can not only move their hips, legs, and toes, but they can also *sense* them and their relation to their corporeal schema and can increase their muscle strength and stamina in their lower body. They have also been able to decrease the amount of necessary stimulation necessary over time, as they have engaged in intense therapy and training.<sup>ii</sup>

The patient controls the stimulator with a remote about the size of a cellphone. When the device is turned on, the stimulator delivers a low level of electricity at varying frequencies throughout the spinal cord and induces a tingling sensation in the lower limbs. Originally designed as a tool for pain management, lead researcher Dr. Susan Harkema at

the University of Louisville was using it in a study to analyze nerve damage when her first patient, Rob Summers, shocked her one day when he decided to move his toe while the device was turned on. One could reason that Summers's success was the result of the plasticity or rewiring of the brain over the course of seven months of therapy. It is certainly the case that intense, individualized therapy has been an important contributor to the success of the four patients.<sup>iii</sup> However, this cannot be the only explanation, as the other three men who are part of the study were able to not only wiggle their toes but had success in moving and swinging their legs almost immediately after having been implanted with the device. In a matter of days, they could stand up with minimal assistance with their own hands and could do sit-ups. These were men who had been told that they would never walk again and had been paralyzed between 2–4 years prior to testing.<sup>iv</sup>

It is imperative to stress that these electrical shocks are *not* merely producing an involuntary spasm in the muscles.<sup>v</sup> The electrical impulses from the stimulator is not forcing the four men to move their legs; rather, they can willingly make these movements. Further, and perhaps more shocking, the four men can voluntarily move their legs and even stand with minimal hand support despite the “absence of functional supraspinal connections,” that is, even though medically speaking no complex signals are being sent from the brain to the legs. It appears that the ingenuity of the spinal cord itself is primarily responsible for the movement.<sup>vi</sup> This process of epidural stimulation made national headlines in 2014, and the research is ongoing with hopes of implanting the device into more paralyzed patients and assessing their success.<sup>vii</sup>

In the following pages I will further discuss the details and successes of this research program. The technological and medical success story provokes a variety of intriguing

questions—questions about the nature of technology and the human, about the nature of human agency and its effect on human psychology, and about the nature of scientific inquiry. However, I am chiefly concerned about what this study reveals about the relationship between the brain and the body, between cognition and action, and between thinking and embodiment. More explicitly, I argue that to speak of a relationship “between” brain and body—even if such language is seemingly impossible to eradicate—is to perpetuate an unnecessary Cartesian dualism. Rather, this research demonstrates that cognition is in some important sense *embodied*, that the body is critically necessary for the brain to properly function, and that our habituation in and attunement toward our everyday activities and environmental context must be understood as forms of thinking that are extended throughout the body.

In order to explicate these conclusions, I will be utilizing the phenomenology of Maurice Merleau-Ponty and recent advances in phenomenological accounts of cognitive neuroscience as my interpretive method for understanding the findings of Dr. Susan Harkema and her research team. In my view, Merleau-Ponty’s philosophical account of subjectivity as fundamentally embodied and intertwined with others and the world is vindicated by these findings on paralysis, and thus, I begin by situating the reader with a brief discussion of Merleau-Ponty’s work and his critique of Descartes. I will then bring his work, specifically his account of habit, into conversation with Harkema’s own theories and reflections on epidural stimulation and its success.

## MERLEAU-PONTY AND EMBODIED COGNITION

Merleau-Ponty (1908–1961) was a prominent twentieth century French phenomenologist, existentialist, and psychologist whose work has had a profound influence on

many fields of inquiry, most notably for the purposes of this essay, in the areas of perception, intersubjectivity, and child development. Over 70 years before the development of spinal cord epidural stimulation, Merleau-Ponty offered an account of subjectivity that sought to fundamentally overturn Cartesian mind-body dualism.

Descartes famously sets forth an account of subjectivity that relegates embodiment to an ancillary role, which continues to plague the way we think today. Descartes arrives at a detached and disembodied subject in his famous dictum *cogito ergo sum*. He states: "I am therefore precisely nothing but a thinking thing."<sup>viii</sup> Descartes continues: "It is certain that I am really distinct from my body, and can exist without it."<sup>ix</sup> While Descartes maintains that body and mind are much more intimately connected than a pilot is to his ship, he establishes them as two distinct substances. Mind, or soul, has no physical extension, is indivisible, and is immortal; the body has parts, is extended, and is finite. As a result, the *res cogitans* is fundamentally distinguishable from the *res extensa*. Neither the imagination nor the body, the latter of which is "like a machine" and even described as "nothingness,"<sup>x</sup> play a role in my essential selfhood or in my understanding of the essences of objects. The mind alone processes input in order to generate representations and mental judgments about external objects. Descartes writes, "Bodies are not, properly speaking, perceived by the senses or by the faculty of imagination, but by the intellect alone."<sup>xi</sup> On this account, my body, motor capacities, senses, and corporeal placement in the world play *no necessary role* in my understanding of objects. Not only do my sensory, perceptual, imaginative, and affective capacities at most play a secondary role in my understanding of objects, more importantly, they are also not constitutive to my identity as a self. Rather, the self "clearly and distinctly" understands

itself solely through self-reflective cognition, which if connected to the body at all, is limited to the brain alone.<sup>xii</sup>

To this, Merleau-Ponty stresses that thinking is never devoid of context; it is always shaped by my history, language, interpersonal influences, and my bodily attunement toward a meaningful and structured world or environment. Cognitive activities in the brain are deeply intertwined with the embodied, affective, and intersubjective aspects of the human subject, and thus, thinking is not to be reduced to what happens in the brain. Our mental judgments have significance to us because they are intertwined with our corporeal posture in the world and are constituted by our intersubjective relations with others. Our sensorial and perceptual engagement with the world is always on the way to cognitive judgments—they inform our judgments. Prior to cognitively evaluating an object, I have already encountered it within a common, meaningful, and social milieu.

In contrast to the Cartesian account of the subject as a *res cogitans*, Merleau-Ponty stresses that *I am my body*. Against the Cartesian view of knowledge as the “internal adequation of the idea or self-identity of the thing,”<sup>xiii</sup> which reduces knowledge to mental representations, Merleau-Ponty maintains that thinking is a fully embodied event. My body is not primarily an object for me but is precisely the means by which I am connected to and intertwined with the world of objects around me. A fundamental wholism exists between mind, body, and world. Thinking “is not an invisible contact of self with self,” but rather, “it lives outside of this intimacy with oneself, *in front of us*, not in us, always eccentric.”<sup>xiv</sup> The actions we perform, especially those repeatedly—such as walking, writing, typing, reading, playing an instrument, holding objects in our hands, or the gestures that accommodate our speaking—are corporeal

activities we habituate into our ways of existing. They become sedimented into our bodies and do not merely “supplement” our cognitive acts but are part and parcel of what thinking *is*.<sup>xv</sup> This process of sedimentation means that our embodied experiences and repeated exposure to physical objects alter the way we think and inform how we go about our daily lives.<sup>xvi</sup>

It is important to stress that such sedimentation on the cultural and social level occurs immediately. Merleau-Ponty writes, “This ‘culture,’ under the sedimentation of human activities, constantly impregnates the newborn from the first day. The individual lives with the demand to take up attitudes that contribute to form this context.”<sup>xvii</sup> On the day of our birth, we are introduced to a world of cultural artifacts, to voices that meaningfully direct us, and to faces that we can imitate.<sup>xviii</sup> Indeed, on the behavioral, sensorial, and perceptual levels, this sedimentation already takes place *in utero*. In the second trimester, the fetus can already hear the mother’s voice and will have the capacity to distinguish it—and prefer it—from other voices at birth.<sup>xix</sup> And between 12–15 weeks (end of first trimester and into the second), fetuses can bring their hand to their mouth 50–100 times per hour, thus priming them for a “centrally organized coordination that eventually comes to be controlled proprioceptively.”<sup>xx</sup> In other words, at birth, the infant already has a body schema, an intuitive understanding of the connectedness of its various body parts, and an ability to meaningfully imitate the behaviors of others.

This embodied way of thinking is easily observed in what commonly goes under the rubric of habit. In the habits that make up our everyday lives, our bodies have a practical know-how for acting upon and responding to objects, but this knowing is not merely a kind of intellectualism that reduces thinking to mental representations. Nor are habits

merely a bunch of instincts or conditioned reflexes.<sup>xxi</sup> Rather, it is a kind of “communion with the environment.”<sup>xxii</sup> Habit, Merleau-Ponty adds, is a “form of [practical] intelligence [that] is not conscious of itself,” which resides in my corporeal posture toward the world and not in the brain alone.<sup>xxiii</sup> Elsewhere, he writes that habit “is knowledge in the hands, which is forthcoming only when bodily effort is made, and cannot be formulated in detachment from that effort.”<sup>xxiv</sup> It is an affective and active relationship between the body and the world of things by which the self intuitively understands this relation but can also fluently improvise and adapt it to new situations.

As a case in point, consider the act of typing, which I did while writing this essay. I can type around 90 words per minute, and such a speed requires a thorough intimacy with the location of the letters on the keyboard that is only learned through extensive practice and experience. When I type words at this speed, I do not have time to make a mental representation of each letter of each word that I write, nor do I have a mental image of the location and image of each key on the keypad. I don’t need to. Rather, the keys are an extension of my fingers, which work in intimate connection with my entire body. As Merleau-Ponty puts it, “When I sit at my typewriter, a motor space opens up beneath my hands, in which I am about to ‘play’ what I have read. ... It is the body which ‘understands’ in the acquisition of habit... To understand is to experience the harmony between what we aim at and what is given, between the intention and the performance—and the body is our anchorage in a world.”<sup>xxv</sup> In short, the fingers serve as an extension of the mind and the keyboard keys are likewise an extension of the fingers.

But it is also my attunement to the entire situation of my laptop and my surroundings that allows me to accomplish the act of typing. It is not merely my fingers, but my entire

posture while sitting at my desk, the shape of my hands over the keyboard, and my being “in the zone” of my office space that contribute to both thinking and action. In fact, some research suggests that in some cases, physical movement or “motor preparation” appears to *precede* intentionality, that is, our bodies anticipate the necessary action *before* the brain tells the body to act.<sup>xxvi</sup>

Or consider playing a sport like baseball or basketball. Shaun Gallagher notes that my capacity to play the game involves a fundamental attunement between my body and the physical and social context in which the game is played. When catching the ball, “The physical environment, the size and shape of the ball, along with the effects of all my previous practice (or lack thereof), and even the rules of the game as they are habitually expressed in the practiced movements of my body, may define how I jump to make the catch. . . . The body schema is much more selectively attuned to its environment than what physiology on its own will specify.”<sup>xxvii</sup> My hand learns how to conform to the contours of the ball in ways different than how my hand prepares to pick up a coffee mug or pick up my laptop. The hand can become so habituated into these behaviors that it takes these shapes without the brain explicitly telling it to do so. But it is important to add that habit is not limited to special skills that we develop. We are engaging in hundreds of habits on a daily basis—putting on clothes, driving to work, riding the elevator, brushing our teeth, and even walking or sitting in our own peculiar way. These are all things that we effectively perform with little explicit thought as our body has lived into these practices.

Habit is a mode of thinking *in* the body, which lends support to the idea that cognition is fundamentally embodied. Supporters of the position of embodied cognition point out that much of contemporary cognitive neuroscience

continues, as Dan Zahavi writes, to be “bedevilled by a crypto-Cartesian and empiricist legacy. It might have replaced the immaterial Cartesian mind with the material brain, but it has maintained the dualism between brain and body, and thereby the logical structure of dualist psychology.”<sup>xxxviii</sup> Mark Rowlands notes that despite its rejection of Descartes’s account of a nonspatial soul, the predominant current view of the mind as a neural network “left intact the second defining idea of the Cartesian conception: the idea that the mind is something that exists inside the head.”<sup>xxxix</sup> This view of mind simply as “embrainment,” as David Morris suggests, reduces the body to a “dumb machine” that passively receives all of its commands to move from the motherboard, the brain.<sup>xxx</sup>

For examples of this continued acceptance of Cartesian thought, consider the standard, prevailing views of theories of mind. Both theory theory and simulation theory depict cognition as a fully conceptually based process that is separate from perception, which “involves a retreat into a realm of *theoria* or *simulacra*, into a set of internal mental operations.”<sup>xxxxi</sup> On these accounts, for the perception of an object to be meaningful and understandable, the brain must perform a secondary, higher-level function than what is accomplished on the level of perception. Importantly, this function involves an interpretation or translation of the perceived object through a conceptual or representational mechanism. On these accounts, observing the shock of pain on another’s face, for example, is not understandable in its own right, but is “theoretical, inferential, and quasi-scientific in nature” (in the case of theory theory), or requires an analogical maneuver whereby the other is understood through an introspective projection of myself (in the case of simulation theory).<sup>xxxii</sup>

In response, theorists who have brought phenomenological inquiry to bear on cognitive neuroscience insist that mental phenomena are not limited to the head; rather “the mind can extend out into the body and even into the world.”<sup>xxxiii</sup> On this view, thinking is fundamentally embodied throughout our organs and is perhaps even embedded within the world around us as the brain requires “the right environmental scaffolding” in order to do its work.<sup>xxxiv</sup> My hand gestures do not merely *help* me to get my points across, they are part of the means by which I develop my ideas. The keyboard upon which I type, by engaging both of my hands at once rather than one (as in the case of handwriting), reshapes the way the brain functions and interacts with its environment. And the process of conversing with my friend actually expands my thinking and reveals new ideas within me that I did not know I even had.

As a result, this means that in our routine, everyday encounters with others and the world, perception is often immediate. The shock of pain on the face of the other is understood directly on the level of perception and without mediation by some complex, mental, representational process. We do not have to conceptually postulate whether the person is thinking about pain or whether the other person has a *cogito* like we do. The person’s “mind” isn’t hidden from us; rather, the person’s thoughts are manifested explicitly through his or her bodily comportment and facial expressions.<sup>xxxv</sup> For sure, self-reflective cognition is necessary for abstract philosophical thought or mathematical equations, but this a derivative mode to our habitual way of encountering the world.<sup>xxxvi</sup>

## EPIDURAL STIMULATION AS EVIDENCE FOR EMBODIED COGNITION

Rowlands, echoing Merleau-Ponty, admits that such an account of mind “will strike many as a truly crazy idea that no one who is even remotely sane could ever accept.”<sup>xxxvii</sup> And yet this is precisely what is being suggested through the current research of spinal cord epidural stimulation. In parsing Susan Harkema’s personal comments about the project, it seems clear that she admits that she began the project with the presumption of the aforementioned Cartesian model. In one interview, she states: “We had always believed that human movement was controlled by the brain and the spinal cord was simply a conduit for those brain commands.”<sup>xxxviii</sup> Here Harkema echoes the revised Cartesian account of mind that reduces the mind-body relation to a series of networks or connections that process the discrete inputs by the brain in a computational manner. On this account, the brain sends complex symbols or messages to the rest of the body, which is reduced to an object that is activated and controlled by the brain. However, the conclusion of the trials suggests something more in line with Merleau-Ponty’s account. Harkema continues:

But the results of these experiments suggest to us that the human spinal cord has a tremendous capacity for recovery even without reconnecting to the brain, that the spinal cord itself integrates complex signals from its environment and signals from the brain to then decide by itself what movement will happen and then execute that movement. . . . The details of the movement, of the control of movement, are really at the level of the spinal cord.<sup>xxxix</sup>

In other words, to some degree the spinal cord functions on its own by means of its own unique form of intelligence and utilizes present and previous experiences in order to know how to respond to its environment. The paralyzed subjects in the experiment regain movement despite the loss of a complex neural connection with the brain—the paralyzed bodies can adapt to this new orientation to the world—because their bodies are functioning within a meaningful, embodied history of encountering the world, because they are drawing on a wealth of previous embodied habits and behaviors. When Harkema states that the spinal cord draws information “from its environment,” she is suggesting that embodiment and social context are not secondary but *central* to the very process of thinking, thus revealing a fundamental interdependence between self and world. Our body helps us to articulate our thoughts; our physical environment informs our mind of meaningful responses to external stimuli.

If no complex signals are being sent from the brain to the body, then how are the four men able to willingly move their legs? It appears that the researchers remain open to two possible hypotheses. The first account theorizes that the brain is sending minimal, untraceable signals of intentionality to the limbs.<sup>x1</sup> On this hypothesis, the four paralyzed participants can transmit the command to intentionally move their lower limbs because the intense therapy and exercise, along with the presence of the stimulator, has led to a rewiring of the brain and its neural networks. In other words, because of the plasticity of the brain, it could be that the brain is learning how to send information through alternative, though undetectable, pathways. Even if this theory is correct, it should be stressed that it is not the body that learns from the brain in this case, but quite the opposite, the brain is learning *from the body*. Echoing the Merleau-Pontyan account above, Harkema adds that we now must assign a certain degree of intelligence

to the body, especially the spinal cord. In her interview, she concludes:

The spinal cord is as smart as the brain and that's what these experiments are telling us. It can remember, forget, make decisions, create signals that control the muscles in a complex way, create commands, and I would even say, teach. What may be happening . . . is that the spinal cord is teaching the brain a brand new way for sending signals.<sup>xli</sup>

This would be consistent with the findings of the field of phenomenological cognitive neuroscience. Again, Gallagher notes, “The brain, thanks to its plasticity, is shaped in part by the body’s movement. It is also clear that the organization and functioning of the brain depend on certain ‘adjustment reactions’ that take place throughout the body.”<sup>xlii</sup> The paralyzed men, in trying to learn how to stand again, are providing feedback to the brain and helping it learn new neuronal pathways that allow it to send and receive information.

Harkema’s comments also imply that the researchers remain open to an even more radical, second hypothesis. This account suggests that the spinal cord has been reawakened to its own potential for action and *needs no further input from the brain* in order to learn from and interact with its environment and to give instructions to the rest of the body.<sup>xliii</sup> The researchers suggest that “human spinal circuitry” is enough “for eliciting motor patterns sufficient for standing” and that “supraspinal structures [are] not required to achieve full weight-bearing standing.”<sup>xliv</sup> The researchers believe that the electrical impulses from the stimulator “altered the excitability of the spinal circuitry allowing the load bearing related sensory information to

drive the circuitry to generate extensor motor patterns that supported standing *without external assistance*.<sup>xlv</sup> On this reading, given that no complex signals from the brain can be detected, it would appear that the rewiring occurs on the level of the spinal cord alone. A “reorganization of the underlying spinal circuitry” occurs due to the “plasticity of the spinal neural circuitry.”<sup>xlvi</sup> The results of the presence of the stimulator, along with intense training and therapy, the researchers note,

demonstrate the ability of the spinal networks to learn with task-specific training and improve motor pool recruitment. . . . Conceivably, after repetitive epidural stimulation and training, plasticity of these disrupted pathways could have resulted in a more functional state. The newly established functional connectivity presumably involves multiple, novel neuronal pathways and synapses.<sup>xlvii</sup>

On this reading, the stimulator effectively reawakens the circuitry within the spinal cord itself and reminds it of its potential for meaningful, life-giving activity. In other words, as I interpret this hypothesis, the body is being reminded of its basic, fundamental habits—of its thousands upon thousands of experiences of movement, walking, standing, and interaction with the environment—that are still ingrained within the body’s memory. In an intriguing sense, this could be said to be analogous to Plato’s account of knowledge as recollection from the *Meno*. However, whereas for Plato, knowledge is obtained by the mind alone by remembering what it had known from a previous life or a kind of mind to mind communion with the Forms, in this case the knowledge is embodied and constitutes a reawakening of the habits and meaningful interaction with

the physical environment that the body had prior to the spinal cord injury.

Even if some undetected signals are coming from the brain, there is no doubt that the body has been reawakened to meaningful activity and to communication with itself as a result of the epidural stimulation and intense therapy. This can be observed in the holistic improvements that have resulted in the four patients. Typically, when we think of the effects of spinal cord injuries, we only consider how they result in an inability to walk or feel the lower limbs. However, many quadriplegics and paraplegics also lose their capacity to control their bladder and bowel movements, to have sex, to regulate their body temperature, and to regulate their cardiovascular and respiratory systems. Amazingly, the researchers additionally report: “Other impairments . . . began to improve over time, *in the absence of stimulation*, such as blood pressure control, body temperature regulation, bladder control, and sexual function.”<sup>xlvi</sup> In other words, due to the epidural stimulation—again in patients who are sensory and motor complete—the four men have regained control of their cardiovascular health, their ability to regulate body temperature (e.g., sweat), and their capacity to have sex even when the stimulator is no longer turned on. The epidural stimulation is not merely simulating the kind of communication that the body would otherwise be receiving from the brain, but it functions as a kind of defibrillator that awakens the body to its meaningful purpose in the world, reinvigorates its ability to communicate with itself, and reveals a kind of sense or understanding that permeates throughout the body itself. Indeed, one might say that these basic bodily processes “accompany and are implicit in every kind of behavior and consciousness so that they define what is possible for behavior and consciousness but in such a way that they remain non-conscious.”<sup>xlix</sup> The *body* is telling itself to regain these basic bodily functions because the movement

in the lower limbs has informed the body that it is still alive and should remain so in order to actively engage with the world. And thus by reawakening these fundamental bodily processes, the body prepares itself for the possibility to stand again.

## CONCLUSION

In the past, some scholars have criticized Merleau-Ponty's phenomenological analyses of psychological and physiological phenomena, lamenting that "unless these [after-the-fact] interpretations are subject to further empirical testing, they remain unverified," and thus, his conclusions remain "simply one of several possible theoretical accounts."<sup>1</sup> The groundbreaking results of epidural stimulation and the interpretation of researcher Susan Harkema's scientific data from these paralyzed patients who can now stand, however, provide the kind of empirical testing that gives credence to Merleau-Ponty's insistence that thinking extends beyond the brain and is embedded in the body's habitual encounters with the world. This essay makes manifest the possibilities for "mutual enlightenment between phenomenology and empirical science"<sup>ii</sup>; however, further research and commentary is needed in order to determine the extent to which this embodied thinking goes beyond the spinal cord and into other parts of the body, to assess what aspects of Merleau-Ponty's thinking should be tweaked or rejected as a result of contemporary findings in cognitive neuroscience, and to consider the implications of this research for other fields of scientific inquiry and philosophical accounts of the subject.

## NOTES

- <sup>i</sup> Rejc, Angeli, and Harkema, “Effects of Lumbosacral Spinal Cord Epidural Stimulation,” 11.
- <sup>ii</sup> See Angeli et. al., “Altering Spinal Cord Excitability,” 1394–95, 1398, 1407; Rejc, Angeli, and Harkema, “Effects of Lumbosacral Spinal Cord Epidural Stimulation,” 1–2, 4. While not a traditional academic source, a brief overview about the device and its success, including interviews with Dr. Susan Harkema and other researchers can be viewed at <http://www.reevebigidea.org/the-research>.
- <sup>iii</sup> “We have highlighted the importance to select individual-specific parameters in order to achieve standing with the least amount of assistance: stimulation parameters optimized for one individual resulted in poor standing and additional need of external assistance for hip and knee extension in the other participants” (Rejc, Angeli, and Harkema, “Effects of Lumbosacral Spinal Cord Epidural Stimulation,” 11; see also 16).
- <sup>iv</sup> Angeli et. al. “Altering Spinal Cord Excitability,” 1394–95; Rejc, Angeli, and Harkema, “Effects of Lumbosacral Spinal Cord Epidural Stimulation,” 1, 6.
- <sup>v</sup> Rejc, Angeli, and Harkema, “Effects of Lumbosacral Spinal Cord Epidural Stimulation,” 12.
- <sup>vi</sup> *Ibid.*, 1. The researchers add, “The lumbosacral circuitry of the research participants was considered functionally isolated from supraspinal influence since they were classified as motor complete. . . . In addition, all other neurophysiological assessments performed without lumbosacral epidural stimulation did not indicate functional connectivity across the injury level suggesting that any of the above mentioned EMG modulation would be predominantly generated at the level of the human spinal cord” (12). In their previous paper, they noted that they tested for “residual descending input to the spinal circuitry” and concluded: “No changes were seen in the ability to activate motor neurons below the level of the injury during active voluntary attempts. No functional connectivity between the supraspinal and spinal centres below the level of injury was detected with clinical or neurophysiological assessments in any of the four subjects” (Angeli et. al., “Altering Spinal Cord Excitability,” 1395, 1396).
- <sup>vii</sup> See, for example, Fox, “The Wind on My Legs”; Flatow, “Reawakening Limbs after Years of Paralysis”; Fletcher, “Epidural Stimulation Shows Promise”; Cohen, “Spinal Cord Work is an Unexpected Shocker”; Cohen, “How Paralyzed Patients Are Able to Stand Again.” The researchers have since expanded the number of individuals in the research program to 12 and are raising funds so that

more participants can be involved (Fletcher, “Epidural Stimulation Shows Promise”).

<sup>viii</sup> Descartes, *Meditations on First Philosophy*, 65, cf. 79, 97, 102.

<sup>ix</sup> *Ibid.*, 97

<sup>x</sup> Descartes, *Discourse on Method*, 32; *Meditations*, 82. For Descartes “the finite has nothing positive about it” (51).

<sup>xi</sup> Descartes, *Meditations on First Philosophy*, 69. For more on how Descartes’s cognitivism continues to shape discourse in cognitive neuroscience and philosophy of mind, see Evans, *The Multivoiced Body*, 95–109, 320n46; Rowlands, *The New Science of the Mind*, 10–13, 21–22.

<sup>xii</sup> “Moreover, I find in myself faculties for certain special modes of thinking, namely the faculties of imagining and sensing. I can clearly and distinctly understand myself in my entirety without these faculties, but not vice versa...I perceive them to be distinguished from me as modes from a thing” (Descartes, *Meditations*, 97–98). “My mind is not immediately affected by all the parts of the body, but only by the brain, or perhaps even by just one small part of the brain, namely, by that part where the ‘common’ sense is said to reside” (102). Descartes appears to have believed that the mind is located near the “brain’s pineal gland” (Rowlands, *The New Science of the Mind*, 11).

<sup>xiii</sup> Merleau-Ponty, *The Visible and the Invisible*, 127.

<sup>xiv</sup> *Ibid.*, 234.

<sup>xv</sup> Rowlands, *The New Science of the Mind*, 11, 17, 21. See also Evans, *The Multivoiced Body*, 94–116.

<sup>xvi</sup> Dan Zahavi writes regarding sedimentation, “What I have learnt in the past does not leave me untouched. It shapes my understanding and interpretation of new objects by reminding me (in a completely tacit manner) of what I have experienced before” (Zahavi, *Self and Other*, 132).

<sup>xvii</sup> Merleau-Ponty, *Child Psychology and Pedagogy*, 99.

<sup>xviii</sup> Cf. Gopnik, Meltzoff, and Kuhl, *The Scientist in the Crib*, 24, 27–30. See also Trevarthen, “The Self Born in Intersubjectivity,” 145; Hobson, *The Cradle of Thought*, 31–32, 34.

<sup>xix</sup> Stern, *The Interpersonal World of the Infant*, 92. See also Gopnik, Meltzoff, and Kuhl, *The Scientist in the Crib*, 27–28. Other research suggests fetuses can respond to auditory stimuli as early as 19 weeks (Hepper and Shahidulla, “Development of Fetal Hearing,” F81–F87).

<sup>xx</sup> Gallagher, *How the Body Shapes the Mind*, 95.

<sup>xxi</sup> Merleau-Ponty, *Child Psychology and Pedagogy*, 196.

<sup>xxii</sup> *Ibid.*, 140. “In the classic view, habit does not concern the mind, but the body” (139). But habit “is neither a question of mechanical actions nor of intellectual operations. ...The problem can be resolved if

perception and motor functions are not artificially separated. In this way, the issue would always involve a certain perception of the situation, on the condition that one grants that this perception behaves according to a corresponding motor adaptation. ...Child behavior develops not only under the influence of physicochemical stimuli, but also out of a communion with the environment” (140).

xxiii Ibid., 212. Bracketed material in original.

xxiv Merleau-Ponty, *Phenomenology of Perception*, 166.

xxv Ibid., 166–67.

xxvi Cole, “Agency with Impairments of Movement,” 657.

xxvii Gallagher, *How the Body Shapes the Mind*, 142–43.

xxviii Zahavi, “Naturalized Phenomenology,” 13n3. Cf. Morris, “Empirical and Phenomenological Studies of Embodied Cognition,” 236, 240–41.

xxix Rowlands, *The New Science of the Mind*, 12; cf. 2–3.

xxx Morris, “Empirical and Phenomenological Studies of Embodied Cognition,” 240–41.

xxxi Gallagher, *How the Body Shapes the Mind*, 211.

xxxii Ibid., 193, 194–95; cf. 196–99, 220–27. For a longer reading of both theory theory and simulation theory, and how they have become more nuanced in recent years, see Zahavi, *Self and Other*, 107–11, 150–73.

xxxiii Rowlands, *The New Science of the Mind*, 7; cf. 13, 21.

xxxiv Ibid., 4.

xxxv Already as *infants* we have an “immediate” understanding of the other and can distinguish animate humans from inanimate objects. Thus, prior to language or arriving at an understanding of my self, “at the level of perceptual experience—we *see* or more generally *perceive* in the other person’s bodily postures, movements, facial expressions, directed gaze, gestures, and actions what they intend and what they feel, and we respond in a tightly coupled way” (Gallagher, *How the Body Shapes the Mind*, 208–09). For more on the argument that perception is immediate and direct see *ibid.*, 82, 210; Zahavi, *Self and Other*, 121–27, 155, 164–70.

xxxvi Cf. Gallagher, *How the Body Shapes the Mind*, 212.

xxxvii Ibid., 7.

xxxviii In Flatow, “Reawakening Limbs After Years of Paralysis.”

xxxix Ibid. These succinct and clear comments from the interview are supported by the conclusions stated in the peer-reviewed journals: “The related sensory information was integrated by the spinal circuitry to result in the complex motor pool activation showed during standing. . . . In addition, all other neurophysiological assessments performed without lumbosacral epidural stimulation did not indicate functional

connectivity across the injury level suggesting that any of the above mentioned EMG modulation would be predominantly generated at the level of the human spinal cord” (Rejc, Angeli, and Harkema, “Effects of Lumbosacral Spinal Cord Epidural Stimulation,” 12).

<sup>xi</sup> “We cannot exclude that supraspinal influences contributed to achieve standing since these four research participants were able to voluntarily move their legs when the lumbosacral circuitry was stimulated with specific stimulation parameters” (Rejc, Angeli, and Harkema, “Effects of Lumbosacral Spinal Cord Epidural Stimulation,” 12). This seems to be the position of other neurosurgeons in the field who are outside observers to the research, such as Dr. V. Reggie Edgerton at UCLA (see Kern, “Spinal Stimulation Helps Four Patients”).

<sup>xli</sup> In Flatow, “Reawakening Limbs After Years of Paralysis.” Elsewhere, the researchers conclude, “Conceivably, after repetitive epidural stimulation and training, plasticity of these disrupted pathways could have resulted in a more functional state. The newly established functional connectivity presumably involves multiple, novel neuronal pathways and synapses (Angeli et. al., “Altering spinal cord excitability,” 1407).

<sup>xlii</sup> Gallagher, *How the Body Shapes the Mind*, 143.

<sup>xliii</sup> “These findings highlight the potential of the human spinal circuitry and its capability to generate motor patterns effective for standing *in the absence of functional supraspinal connections* when epidural stimulation is provided (Rejc, Angeli, and Harkema, “Effects of Lumbosacral Spinal Cord Epidural Stimulation,” 16; italics mine).

<sup>xliiv</sup> *Ibid.*, 12.

<sup>xliiv</sup> *Ibid.*, 14; italics mine.

<sup>xliiv</sup> *Ibid.*, 15.

<sup>xlvii</sup> Angeli et. al., “Altering Spinal Cord Excitability,” 1407. There is, perhaps a third hypothesis that is related to this second one. Dr. Roderic Pettigrew, director of the National Institute of Biomedical Imaging and Bioengineering (NIBIB), who has closely observed the research, believes that the stimulation is reprogramming or rewiring the damaged nerve cells: “The thinking is that part of the injury process results in loss of nerve cells’ ability to respond as they once did to stimulation at a typical level. . . . What the researchers did not do is to directly excite the nerve cells to the point of triggering a response. . . . Rather, what they were trying to do was re-program the cells to that they respond to input” (Moran, “With the Help of Neurostimulation,” 11).

<sup>xlviii</sup> Kern, “Spinal Stimulation Helps Four Patients”; italics mine. See also Moran, “With the Help of Neurostimulation,” 10.

<sup>xlix</sup> “Neuromuscular activity is an integral part of mental activity. ... They include, for instance, processes that involve physiological tensions, throbbings, and rhythms that accompany normal, untroubled respiration, blood-flow, and heartbeat. Indeed, it is better to say that such prenoetic processes accompany and are implicit in every kind of behavior and consciousness so that they define what is possible for behavior and consciousness but in such a way that they remain non-conscious” (Gallagher, *How the Body Shapes the Mind*, 150).

<sup>l</sup> Gallagher, “Phenomenology and Non-reductionist Cognitive Science,” 26.

<sup>li</sup> *Ibid.*, 32.

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