Neuroscience, Education, and a Radical Embodiment Model of Mind and Cognition

Clarence W. Joldersma
Calvin College

Recent research in neuroscience has a seductive appeal for quick applications to many everyday phenomena.[1] This research has also attracted educational entrepreneurs, who often create commercial programs that turn neuroscience into classroom practice.[2] Phrases such as "brain-based education" give them an air of respectability and authority, enticing educators to adopt them. However, basic brain research is often superficially understood, and thus translated too quickly into educational practices.[3] The large gap between neuroscience and practice is ignored too often by entrepreneurs selling their programs. They often end up making inflated claims about neuroscience's direct benefits in day-to-day teaching practices. Problematizing this is a good public service for philosophy of education.

Francis Schrag has recently published a critical review of two books exploring the connection between neuroscience and education.[4] The article is a welcome entry into the conversation in philosophy of education.[5] Schrag has carefully thought about the role neuroscience plays in certain entrepreneurial claims about educational practices, especially supposedly *novel* ones purportedly leading directly from basic neuroscience research. His finely tuned philosophical eye insightfully looks for *distinctive* contributions of neuroscience to *new* educational practices, rather than merely how neuroscience might echo what is already practiced in education. In the review Schrag argues that much of what passes for novel insights attributed exclusively to neuroscience actually has older educational sources. Schrag's deflationary argument against hasty translation entrepreneurs is an important public function for a philosopher of education.

Not wanting to be only negative, Schrag ends with some suggestions concerning the possible *positive* pedagogical fruits of neuroscience. One is that "were neuroscience to enhance education, it would be by way of interventions that succeeded in altering the fundamental neural mechanisms found in the brain itself."[6] He goes on to say that neuroscience's basic discoveries "will be translated into interventions designed to affect microlevel processes in order to reduce cognitive *deficits* and enhance performance at the macro level."[7] He is suggesting that the macro-level activities of helping students learn might be aided by intervening directly in the brain's micro-level processes. Responsible neuronal interventions might be neuroscience's contribution to education, especially in medically diagnosed cognitive deficiencies.

I do not wish to argue directly against Schrag's suggestion about such interventions. However, in this essay I will suggest that we need to go further in our critique. I argue that the philosophical model sustaining the idea of intervention is inadequate. Most of my critique will be in the form of developing an alternative philosophical model, one I call radical embodiment. My aim is to develop a model that more adequately situates the conversation about neuroscience's possible contribution to educational practice, including the idea of interventions.

The idea of neuronal intervention typically relies on a *medical* model of cognitive differences.[8] Here differences such as ADHD or dyslexia are thought of as cognitive deficits and modeled as medical problems,[9] construed as symptoms of underlying neurological issues. On the medical model, because cognitive deficits arise out of brain differences, neuroscience might determine responsible neuronal interventions. The idea of intervention makes most sense if we can rightly assume direct correlations between micro-level brain processes and macro-level educational effects. In turn, this relies on the philosophical model of a one-to-one correspondence between the mind and the brain,[10] something that has been called *supervenience*. Jaegwon Kim describes supervenience as the idea that there is a one-to-one correspondence between a mental state and a brain state, where any difference between mental states correlates to a corresponding difference between brain states.[11] The idea that interventions at the brain level will lead to corrections at the mind level assumes that cognitive difference is a direct function of brain difference.

I believe that this rests on an inadequate philosophical model of the relation of mind and brain, centrally because it disregards the body and environment. Supervenience has neglected the body by assuming that cognition requires only what Andy Clark calls *simple* embodiment.[12] Here the body's role is biological support for the brain as well as constraints on the brain (and mind). I will argue, however, that this is problematic because it leaves more substantive roles for the body and the environment out of the picture. My argument will involve developing an alternative philosophical model, one based on Clark's idea of *radical* embodiment.[13] This integrates more substantively bodily and environmental factors with the idea of cognition. My model complicates the idea of simply intervening in neuronal processes for educational gain.

Clark's idea of radical embodiment entails conceptualizing a more substantive relation among mind, brain, body, and environment. Let us begin with the brain. Although the brain is clearly a complex neural network located inside our heads, it does not yet address how to conceptualize its relation to the body. For that we need to ask, with Arthur Glenberg, "What are brains for?"[14] He argues that brains are not for *thinking*, at least popularly conceived. Nor is it primarily a computational processor doing symbol manipulation. Instead "the basic function of a nervous system is to guide action."[15] He is saying that brains are not primarily geared for interior mental activity in which the body is only a physical support for the brain. Rather, brains should be thought of as geared toward goal-directed action, to activate and coordinate the body's actions in the world. As Alva Noë states, the brain and the nervous system are "in the business of enabling us to interact dynamically with the environment."[16] Rather than interpreting brain states in isolation, they are involved in the dynamic sensorimotor coupling of body and world. The brain is best characterized as a sophisticated routing and mixing mechanism, one that sorts, organizes, and relays important information between the sensory and motor dynamics of bodiliness.

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Further, in radical embodiment, the body is characterized, in Maurice Merleau-Ponty's terms, as the phenomenal body.[17] This means the body is an embodied *subject* that has an intentional relation to the world.[18] As the phenomenal body, it already exhibits intentionality,[19] something Hubert Dreyfus describes as bodily skills, "dispositions to respond to the solicitations of situations in the world."[20] The patterns of sensorimotor activity structure the subject's interactions with the surrounding world, constituting a basic sensorimotor interpretation of its world. This is not a mentalist understanding of intentionality, but intrinsically a *bodily* one. As Evan Thompson says, "What it is to experience the world perceptually is to exercise one's bodily mastery or know-how of certain patterns of sensorimotor dependence between one's sensing and moving body and the environment."[21] Thompson is arguing that a subject as a bodily being gets to know the world by actively moving about in the world. Intentionality associated with the embodied subject integrally involves a set of active sensorimotor patterns dynamically interacting with its environment. The integration of action and perception, motility and sensibility collectively constitute the embodied subject's intentional presence in the world.

The intentionality associated with radical embodiment is non-representational. It is instead connected to what J.J. Gibson calls affordances.[22] Our surroundings afford the embodied subject certain ways of interacting with it based on species-particular bodily shapes and action potential. For example, for most humans a cup affords grasping, lifting to our lips and gentle tipping. Intentionality is not a property of mental representations (a view typically associated with the supervenience, simple-embodiment model), but instead is making sense of the presentational world. As Dan Zahavi states, "Rather than saying that we experience representations, it would be better to say that our experiences are presentational, and that they present the world as having certain features."[23] Affordances constitute informational sensitivity from sensorimotor coupling, which shows up as experiential meaning of the world. The idea of affordances brings together sensory and motor aspects of the bodily subject interacting with its surroundings. The brain, on this understanding, supports the bodily subject's meaningfully making its way in the world via actions the world affords. I am arguing that the brain's central role is to support skillful bodily interactions with the world constituted as a network of affordances. The active, bodily subject's meaningful interaction with the environment is basic, and this is what informs the brain's dynamic patterns. Without the idea of radical embodiment, the brain would be misunderstood. The secret to the brain's overall neural dynamics is bodily-being-in-the-world.

Moreover, this is not a deterministic model. The sensorimotor interaction between the radically embodied subject and the world of affordances is more aptly described as *modulating*, proportionally adjusting and adapting based on continual contextualized feedback. According to Thompson, "sensorimotor coupling between organism and environment modulates, but does not determine, the formation of endogenous, dynamic patterns of neural activity, which in turn inform sensorimotor coupling."[24] Sensorimotor bodily interactions might be based in general dynamic

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schema (such as walking) but are continually modulated by continuous sensory feedback which, precisely as information, can give rise to new ways of enacting the schema of the intentional act of, say, walking. In other words, in the radical embodiment model, bodily interaction with its milieu includes contextualized feedback loops in the larger dynamic system of bodily-being-in-the-world. Brain states are reconceptualized in such an account. According to Thompson, "neural states are described not at the level of their intrinsic neurophysiological properties or as neural correlates of mental states, but rather in terms of how they participate in dynamic sensorimotor patterns involving the whole active organism."[25] Brain states are construed as neural dynamics informed by the meaningful sensorimotor patterns constituting bodily-being-in-the-world and in turn, continually informing those patterns. Localized sensory feedback adjusts and adapts general motor dynamic patterns while, conversely, neural states participate as a bodily-subsystem in the entire bodily subject's action as *informed* by the network of affordances. That is, the relations between neural activity and the sensorimotor elements of embodied environmental interaction are modulating.

This action-based understanding of radical embodiment and intentionality allows us to reconceptualize the idea of mind. Thompson describes the mental aspect of perceptual experience as constituted by "the perceiver's implicit and practical knowledge or skillful mastery of the relation between sensory experience and movement."[26] He characterizes the mind in terms of practical know-how and skillful knowledge that integrates sensory experience with movements. This is different from the supervenience model because it expands the idea of mind to include bodily-being-in-the-world.[27] For one, the senses are not independent of our sensorimotility, spectator-like, but each in its own way shows patterns of dependence on our species-specific ability to move about in the world. For another, bodily actions in the world are not independent of our mental capacities, as if they were merely *caused* by mental states. Rather, the mind involves the sensorimotor patterns of the *whole* embodied subject.

The mind thus supervenes on more than just the brain. Thompson states, "the human mind is embodied in our entire organism and embedded in the world, and hence is not reducible to structures inside the head."[28] His idea of mind extends to the entire phenomenal body, the radically embodied subject. Moreover, this includes its embeddedness in the world. The mind thus does not supervene narrowly on the brain, but also on the entire bodily subject, and that in its relation to the world. In Dan Zahavi's words, "subjectivity is essentially oriented and open toward that which it is not, and it is exactly in this openness that it reveals itself to itself."[29] The mind is not an interior region somewhere in the head but, as Noë suggests, the mind is our skillful familiarity with the world.[30] Perhaps the world itself is an integral part of mind, as "outside memory."[31] The world is shaped as something meaningful, as something we can do things in and make our way about. The mind extends into the world; we experience ourselves *as* minds by being bodily oriented to the world. The mind is a description of our familiarity with the world, of the implicit knowledge of making our way about in that world. The mind needs to be understood in its

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embodiedness, including its embeddedness in the world. Radical embodiment draws attention to the bodily, outward-directed orientation and nature of the mind. The mind's supervenience extends beyond the brain, through the body, indefinitely outward.

We are now in a position to rethink the idea of cognition. In radical embodiment, cognition is understood not only as an active process, but also as being dependent on being a body with certain patterns of sensorimotor actions. At minimum, some argue that cognition simply *is* sensorimotor coordination.[32] This means that in its basic form cognition involves coordinating the sensorimotor behavior of the organism by coupling sensory and motor patterns and capacities. Although this may well show up in rudimentary form even in very simple organisms, in more complex creatures this constitutes a vastly expanded meta-system allowing for exceedingly great flexibility of coordination between sensors and effectors so that the organism can more effectively deal with the complex patterns constitutive of its environment.[33] But even in its flexibility, cognition remains the subsystem organized to connect sensors and effectors for the sake of the embodied subject's making its way about in the afforded world.

In human cognition this idea continues to hold. Human cognition also centrally still involves patterns of sensorimotor coordination. Even in settings where action is not obvious, evidence indicates that certain sensory and motor *actions* are simply bracketed while running on the same neural machinery.[34] Cognition remains subtended by the same neuronal dynamics that support general patterns of sensorimotor skills. This means that cognition centrally involves something that we *do*, aptly characterized by Noë as a "temporally extended process of skillful probing" in which "the world makes itself available to our reach."[35] Further, on this model we can, with Anna Borghi, interpret *concepts* as patterns of potential action or, in line with the idea of modulation, as perceptual dynamics that inform possible actions.[36] A concept can be thought of as that which triggers motor dynamics enabling interactions with environmental objects, either simply or in more complex ways, flexibly and situationally.

Particular concepts emerge via particular networks of affordances. Even merely perceiving objects, without overt movement or action, suggests Borghi, nevertheless activates a sensorimotor dynamic, by triggering "action related properties" which in turn shape the "perceptual processing" of objects.[37] Put differently, information about objects comes in the form of affordances. Having access to the world cognitively means that the world is accessible to sensorimotor skills that mesh with those affordances. As a result, the particulars of the differences between cognitive states, qualitative differences, cannot be explained exclusively in neuronal terms, as the supervenience model suggests. Susan Hurley and Alva Noë argue that "To find explanations of the qualitative character of experience, our gaze should be extended outward, to the dynamic relations between brain, body, and world."[38] They conclude it is not the specific neural activity in isolation that makes the cognitive state what it is. Instead, the secret to cognition involves neural activity in its

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connection to the sensorimotor pathways of the embodied subject's interactions with the world.

This view of cognition can be extended to abstract thought. In abstract thinking, cognition remains geared for action, although with interesting and marked modifications. Even, for example, in mathematical abstractions, cognition remains enmeshed in sensorimotor dynamisms, even though there is no overt sensorimotor activity. For example, mental rotation of objects — something that does not involve overt motor activity — is nevertheless subtended by the same neural motor systems as manual rotation of a similar object.[39] Similarly, there is evidence that the abstract concept of numerical magnitude remains connected to sensorimotor acts of the fingers, continuing to be subtended by those sensorimotor neural dynamics.[40] More generally, there is evidence that mathematical cognition continues to involve sensorimotor patterns that make use of neural dynamics, which are also active in bodily action and perception. Even something as simple as gesturing while developing math concepts is evidence of this.[41] Beyond the field of math, in language use, for example, there is similar evidence. Rather than being an autonomous system, language use is subtended by sensorimotor neurodynamics, redeploying neural structures originally modulated by sensorimotor couplings with the world.[42] More generally, my argument is that the secret to cognition is not the brain's neural states in isolation, perhaps construed as a complex symbol processor and understood separately from its embodiment. Instead, evidence is now mounting that sensorimotor dynamics constitutes cognition even in abstract concepts and language, as we continue to rely implicitly on the network of affordances that shape our embodied interactions with the experienced world, a view called enacted or embodied cognition.[43]

Although abstract thought obviously does not require overt motor interaction with the world, the mind's continued reliance on the same sensorimotor dynamics suggests that cognition does not store separate representational detail of conceptual content. Instead, such content is constituted by access to the network of affordances available to sensorimotor skills. Given the relative autonomy of abstract thought, one way to model this is through the phenomenon of metaphor. What allows cognition its autonomy while remaining dependent on sensorimotor dynamics for content is to think of embodied simulation as metaphorical interpretation.[44] The environment's stability, in terms of its network of affordances, gives abstract thought its stability and groundedness even as it extends the content's possibility via metaphorical translation.[45] This description suggests that, rather than a disembodied spectator, even abstract cognition continues to involve radical embodiment.

The idea of radical embodiment, along with the attendant changes in our conceptions of the body, brain, mind, and cognition, complicates the possible success of the idea of neuronal intervention in cognitive deficits. The radical embodiment understanding of cognition has implications particularly for cognitive differences including, for example, those associated with ADHD and dyslexia. I do not mean merely that these learning deficits may well be a function of problems with sensorimotor patterns. For example, dyslexia has been theorized as caused by

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sensorimotor deficits[46] and sensorimotor training has been suggested for remedying ADHD.[47] I mean we need to move toward a fuller understanding of these cognitive differences, one in which they are understood in terms of embodied or enacted cognition.

On the radical embodiment model, such differences in cognition are not merely a function of neural differences in the isolated brain. They need to be understood in conjunction with the embodied subject's sensorimotor interaction with the perceived world. Cognition is not just in the head, but includes also bodiliness and its affordances. The medical model of applied educational neuroscience rides on a model of simple embodiment, one that addresses the brain in isolation. Certainly, human cognition as we know it would not be possible without a brain. And it is also highly likely that interventions in neural processes will cause *some* changes in cognition. However, the sorts of changes it could bring are not as predictable as educational neuroscience might wish. In radical embodiment, minds do not just neatly supervene on brains. Instead, cognition involves openness to the world, enmeshed in its affordances. On that understanding, changes effected by neural interventions will not necessarily give the *right* sort of changes in cognition. We cannot know the right sort of changes in cognition by manipulating neural changes in the brain alone, in isolation from the body-in-the-world. Because cognition is radically based in sensorimotor patterns, it continues to involve a coupling with the world.

Paul Howard-Jones has insightfully suggested that the idea of learning in neuroscience is not the same as in education.[48] He argues that in neuroscience it is typically reduced to physical memory whereas in education the idea is more expansive, often connected to types and qualities of experiences. Schrag's suggestion about micro-level interventions at the brain's neurological level to address macro-level cognitional differences might well be, in Howard-Jones's terms, a "level of action" error.[49] Learning in the expansive sense is not supervenient on the brain, but on the entire mind-brain-body-world nexus. If cognition supervenes on anything, it would be on the body-in-the-world. As a result, cognitive differences are not merely a function of brain-state differences as the supervenience model holds, but are, to use Noë's phrase, partly outside of our heads.

This has implications for how education might make use of insights from neuroscience, including Schrag's idea that it could inform interventions into cognitive deficits. Negatively, radical embodiment suggests not only that neuro-level intervention would be inadequate, but also that interventions in sensorimotor functions, narrowly construed, would not be sufficient. Instead, calls for resituating neuroscience should proceed similarly to what Howard-Jones names a multiple perspective approach.[50] He suggests varying levels of action ought to be distinguished, including the neural and social levels. He clearly goes beyond the reductionist medical model that uses the traditional idea of supervenience. However, the radical embodiment model suggests that before neuroscience can help education, the research itself needs to be reconceptualized, by making central the role of the brain's relation to the body and world. An educational neuroscience interpreted

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through a radical embodiment model would certainly move away from a simple micro-level intervention to address cognitive differences. However, the idea of radical embodiment would also push neuroscience further by making more complex the model of cognition itself, as something involving the mind-brain-body-environment.

In this essay I have attempted to contribute to the discussion about education and neuroscience by questioning the philosophical model of mind/brain relations that implicitly subtends it. In its stead, I have suggested a philosophical model, called radical embodiment, which I believe will more adequately frame our thinking about the role of neuroscience in educational practice.

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