EDUCATIONAL THEORY

DOES NEUROSCIENCE MATTER FOR EDUCATION?

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Abstract. In this review essay, Francis Schrag focuses on two recent anthologies dealing completely or in part with the role of neuroscience in learning and education: *The Jossey-Bass Reader on the Brain and Learning*, edited by Jossey-Bass Publishers, and *New Philosophies of Learning*, edited by Ruth Cigman and Andrew Davis. Schrag argues that philosophers of education do have a distinctive role in the conversation about neuroscience. He contends that the impact of neuroscience is likely to be substantial, though not in the way its advocates imagine. It has the potential to enhance education by way of interventions that successfully alter the fundamental neural mechanisms of learning, but neuroscience is unlikely to affect classroom teaching substantially.

The last couple of decades have seen an explosion of research on the human brain. Substantial progress in uncovering the mysteries of the material basis of human cognition has resulted from several strands of research: One strand employs new imaging technologies that enable investigators to identify the specific brain structures activated when subjects tackle diverse problems in the laboratory. Another strand investigates the molecular and cellular processes that underlie learning and memory. A third strand investigates the genetic mechanisms responsible for abnormal brain development. A few educational researchers have been quick to recognize that the new, more sophisticated understanding of the brain that is emerging may hold great promise for educators. Graduate programs in neuroscience and education have been established at major universities, including Cambridge and Harvard. In 2007 *Mind, Brain, and Education*, a quarterly journal devoted to scholarship on the brain and behavioral issues as these relate to the field of education, was launched and was named "best new journal" in the social sciences and humanities for that year. Furthermore, "brain-based learning" has become a buzzword in our general discourse.

Compared with the United Kingdom, few philosophers in the United States have engaged with this movement. This is somewhat surprising, given the centrality of the mind-brain relationship in philosophy since Descartes. Perhaps the reason for the apparent lack of interest is that we have been preoccupied with issues that are more overtly political, such as accountability, inequality, and multiculturalism.

Whatever the reason, however, it is unfortunate that we have not focused on this new development because I believe philosophers are well placed to offer a valuable perspective on the movement. Not that we have a superior — or indeed any — basis for predicting where the science may lead; even the best scientists are poor at anticipating the next breakthrough (or dead end). What invites, even compels, philosophical reflection is a conundrum at the heart of the effort to link neuroscience and education: viewed one way, the marriage between the two can be seen as entirely natural and certain to produce brilliant progeny; viewed another way, the union appears to be forced, unnatural, and unlikely to offer much of practical use.

The case for the union is most succinctly stated at the end of Kurt Fischer and Mary Helen Immordino-Yang's introduction to *The Jossey-Bass Reader on the Brain and Learning*: ''The brain is the central organ for learning, and scientific research on learning and the brain promises many important new insights and tools that will improve education around the world.''[1] If we add an intermediate premise stating that learning is central to education, a premise that should evoke little objection, we have what appears to be a highly plausible chain of reasoning. But now imagine an elementary school teacher, many of whose fifth-grade students, despite having mastered the multiplication of two-digit numbers by ten, don't have a clue about how to multiply two-digit numbers by 100. Or imagine a high school English teacher, many of whose twelfth graders can't understand the first lines of Andrew Marvell's *To His Coy Mistress*: ''Had we but world enough, and time, This coyness, lady, were no crime.''

Can you even invent a story about how neuroscience could help these teachers? Would a brain scan of the children offer any clues as to how to proceed? The idea seems ludicrous. But perhaps this kind of problem, focused on a few children in a particular class, is not one that neuroscience can be expected to help with. Consider more general questions of educational policy such as whether seventeenth-century British poetry is even appropriate for American high schoolers, whether the fifth graders should be using calculators to solve mathematics problems like the one just mentioned, or whether boys and girls should be in separate classes for mathematics. It is still difficult to see how, for all its potential power to explain *why* certain practices succeed or fail, neuroscience could help us answer such questions about what to *do*.

I do not mean to call attention to the problem of drawing normative conclusions from empirical premises, nor to the problem of applying scientific understanding, focused not on anyone's individual brain but on brains in general, to a particular case. Scientific advance never eliminates the need for normative justification nor does it eliminate the need for sound and nuanced judgment. But the development of medicine and agriculture over the last half century bears witness to links between more effective practices and scientific advancement. The problem is to see how the findings of neuroscience might conceivably bear on educational decisions or practices to enhance educational effectiveness. And yet, as neuroscience discovers more and more about the mechanisms of learning and

1. Jossey-Bass Publishers, ed., *The Jossey-Bass Reader on the Brain and Learning* (San Francisco: Jossey-Bass, 2008), xx and xxi. This work will be cited in the text as *BL* for all subsequent references.

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memory, how could those discoveries not be relevant, even important, for those trying to educate, often with little or no success?

In this review essay, I address this issue through an analysis of two recent anthologies that deal with the role of neuroscience in learning and education: *The Jossey-Bass Reader on the Brain and Learning*, a compilation produced by Jossey-Bass Publishers, and *New Philosophies of Learning*, a collection of essays edited by Ruth Cigman and Andrew Davis.[2] I begin by assessing some of the neuroscientists' own efforts to give educators reasons to think their work might matter to classroom teachers. Next, I canvass some philosophers' efforts to grapple with the new field. Finally, I propose my own solution to the conundrum.

Neuroscientists on Education

Since all educators are interested in learning and the brain is centrally involved in all learning, one plausible suggestion is that neuroscientists can provide scientifically sound general guidance for educators. Usha Goswami, director of the Center for Neuroscience in Education at the University of Cambridge and one of the leaders in the new field, attempts to provide such guidance in her contribution to *New Philosophies of Learning*, "Principles of Learning, Implications for Teaching: A Cognitive Neuroscience Perspective." In this article, Goswami identifies six "principles of learning demonstrated by empirical studies *that can safely be incorporated into education and teaching*" (*NPL*, 32, emphasis added). Scrutinizing these should provide an initial indication of the potential of recent research linking neuroscience and education.

Goswami's first principle states that learning is incremental and experience-based. She discusses how a number of visible behavioral phenomena, such as "critical periods" for certain types of learning or difficulties in acquiring a second language in adulthood, can be explained by the incremental growth of neural structures of increasing complexity. This shows how neuroscience can *explain* behavioral phenomena, but how can this information be used to *enhance* our educational efforts? In addition to a few vapid guidelines — for example, that educational environments should not "feel unsafe or stressful" (*NPL*, 33) — Goswami contends that "the biological necessity for learning to be incremental questions the notion that we can ever engender 'conceptual change'" (*NPL*, 33). But I wonder whether Goswami has this backward. Conceptual change is a robust experiential phenomenon, as anyone who has learned to see the physical world through Newtonian rather than Aristotelian eyes or who has replaced a monotheistic worldview with a secular one (or the reverse) can attest. The burden of proof is on the neuroscientists to discover the neural processes that underlie such transformations, which are often experienced as anything but incremental. The failure of current, connectionist models of neuronal activity to explain these

2. Ruth Cigman and Andrew Davis, eds., *New Philosophies of Learning* (Chichester, UK: Wiley-Blackwell, 2009). This work will be cited in the text as *NPL* for all subsequent references.

conceptual shifts shows a limitation of the models; it doesn't challenge the existence of the phenomenon.

A second principle asserts that learning is ''multisensory,'' leading to the recommendation that children be taught using a variety of their senses so that ''learning will be stronger (that is, learning will be represented across a greater network of neurons, connecting a greater number of different neural structures, and accessible via a greater number of modalities)'' (*NPL*, 34). But as Goswami herself recognizes, the equation of ''more neural structure'' with ''stronger learning'' has yet to be demonstrated empirically. Furthermore, even were this to happen, the neuroscience would only help *explain* the stronger learning; it would not be needed either to generate or to test the proposition that ''multisensory'' teaching enhances student learning.

Goswami's third principle claims that brain mechanisms of learning extract structure from input so that ''the brain will extract and represent structure that is present in the input *even when it is not taught directly*'' (*NPL*, 35). But is this really news? Have neuroscientists never heard of the ''hidden curriculum''? The only recommendation that emerges is the banal one that an optimal balance of direct teaching and discovery learning must be found.

The fourth principle states that learning is social: ''The wealth of studies of infant and animal development are showing more and more clearly that the complex mammalian brain evolved to flourish in complex social environments'' (*NPL*, 36). Goswami, citing Lev Vygotsky's research, claims that this shows ''learning with others is usually more effective than learning alone'' (*NPL*, 37). So far as I know, no educator, not even Jean-Jacques Rousseau, proposed that the best learning is solitary. Be that as it may, note that Vygotsky needed no brain imaging, no neuroscience, to reach his conclusions. I wonder, moreover, whether the current understanding of the social brain might just as plausibly yield a quite different conclusion: not that learning alone is more effective, but that teachers are more effective when there are fewer other children around. The brain evolved long before there were books, schools, and classrooms. Might one not see a roomful of thirty or so children — in contrast to a single tutor, for example — as offering an almost insuperable distraction from the needed concentration, concentration abetted by enabling the social brain to go temporarily ''off line''? Might the best conditions for academic learning be periods of intensive one-on-one learning punctuated by periods of free play with peers? I do not mean to suggest that this conclusion is necessitated by neuroscience, only that it is not ruled out. In other words, neuroscience offers little guidance. I will forego discussion of the final two principles, that ''cognitive learning can be modulated by phylogenetically older systems'' (in other words, that emotions affect learning) and that ''learning shows life-long plasticity and compensation'' (*NPL*, 36–38). As far as I can see, the entire set of principles only dresses up in fashionable neuroscientific attire the intuitive knowledge shared by experienced teachers.

Granted the field of educational neuroscience is young, but one searches in vain through the Jossey-Bass anthology that purports to give educators an overview of what is known about the brain and learning for signs that the educational potentials of neuroscience ''are indeed enormous.'' Curiously, the articles cited in the introduction as providing the best glimpse of this potential are not included in the volume. For the most highly developed domains, Fischer and Immordino-Yang do, however, point the reader to part 5, ''The Learning Brain: Language, Reading, and Math.'' These chapters, written by recognized leaders in their fields, are indeed among the most interesting and clearly written. In chapter 15, Uta Frith and Sarah-Jayne Blakemore, two eminent British scholars, explain the way the human brain responded and adapted to the invention of the alphabet and the rise of literacy. Here we learn that in the absence of literacy, people are unable to analyze words into their component sounds (phonemes), and that gaining the ability to do so produces permanent changes in the brain. Moreover, the changes in the brain resulting from learning to read and write depend on the learner's language. People who are literate in English, which has so many words that are not spelled the way they sound, develop different brain structures from those who are literate in Italian, where sound and spelling go together. The chapter is fascinating but makes no pretense of providing a contribution to the teaching of reading or writing.

Much more might be expected from chapter 16, ''Why Some Smart People Can't Read'' by Sally Shaywitz, a recognized leader in research on dyslexia, and chapter 17, ''What Happens in the Brain When Children Read'' by Patricia Wolfe and Pamela Nevills, two successful consultants on neuroscience and education. Shaywitz provides an overview of the nature of dyslexia and of recent advances in our understanding of the condition. According to Shaywitz, our understanding of dyslexia has progressed substantially during the last decade, and dyslexia has been traced to a deficit in ''phonological processing,'' the ability to analyze the individual sounds that words comprise. According to Shaywitz, this understanding did not derive from neuroscience, but is consistent with what neuroscientists know about the brain. Moreover, ''researchers ... have had an opportunity to test and refine this model through reading and, more recently, brain imaging studies'' (*BL*, 246). Nothing in the Shaywitz chapter even gestures toward how what has been learned through brain imaging leads or might lead to enhanced educational interventions. The Wolfe and Nevills chapter offers a more detailed view about what parts of the brain are involved when we read. The authors provide some informative diagrams and flow charts of the ''neural pathway for reading'' (*BL*, 258). Some of the findings they discuss are fascinating and are far from obvious: ''Educators are often surprised to learn that in an fMRI or PET scan (which depicts activity levels in the brain) the auditory cortex is active even when a person is reading silently'' (*BL*, 262). Wolfe and Nevills draw on Shaywitz's research showing that ''there appeared to be two distinct types of brain problems in the dyslexic readers'' (*BL*, 264), and they anticipate how such research may help teachers in the future:

> These exciting new findings have major implications for those who study and teach reading. Researchers, using brain imaging, may be able to validate effective strategies for helping struggling readers as they observe changes that take place in the neural systems for reading as the result of specific reading interventions. (*BL*, 265)

Note that the ''major implications'' are for those who study *and* those who teach reading. Undoubtedly there are implications for those who study reading. But implications for teachers are a different matter. Wouldn't the children's learning to read be validation enough of ''effective strategies''? From the teachers' point of view, knowing which brain structures are involved adds nothing to the success of the strategies.

But might not the knowledge that there are ''two distinct types of brain problems'' lead to better ways of teaching children to read? Let's consider two distinct possibilities.[3]

First, some readers have comprehension difficulties, and these can be localized to a portion of the brain's left hemisphere called Broca's area. A different group of readers has difficulty with phonological analysis, and these difficulties are localized in Wernicke's area of the left hemisphere. Now it is plausible that the students in the two groups require different kinds of remediation, but do we have to know which part of the brain is involved to diagnose the problem or design the remedy? It appears not, because language and reading tests give reading teachers the tools to discriminate between the two kinds of problems. Indeed, it is only on the basis of these tests that we are able to correlate the two kinds of deficit with particular regions of the brain in the first place.

Second, a group of readers appear to encounter the same difficulties in comprehending texts, but the usual remediation for this kind of problem works for only one portion of the group. Brain scans reveal that the group that is not helped by the remediation actually has a ''glitch'' in a different part of the brain (structure x) from those who are helped to overcome their disability. The information taken from the brain scans adds to our knowledge of reading deficits, to be sure, but how does it help remedial reading teachers? Can they develop enhanced interventions based on the knowledge that the problem is localized in structure x? I don't see how. Of course, scanning the brains of all the children with comprehension difficulties might help us identify those not likely to be helped by the usual methods, but wouldn't it be simpler to just try the usual methods and see whether the children can be helped?

My discussion is not meant to deny or devalue the substantial progress made in understanding why some children have difficulty learning to read. Not too long ago, dyslexic children were considered unintelligent, and because of their propensity to write letters backwards, it was widely believed that the source of the difficulty was entirely visual. Now a lot more is known, and neuroscience has contributed to the progress. But the evidence produced gives no real hint of how neuroscience will contribute to the enhanced efficacy of remedial reading teachers.

Stanislas Dehaene's chapter on children's mathematical development (chapter 18), originally published in 1997, and thus perhaps dated, is one of the most

3. My illustration here is deliberately simplified to enable the reader to follow the logic of the argument.

wide-ranging and stimulating in the collection, so I shall spend a little more time with it. Moreover, Dehaene is not shy about prescribing curricular changes. But we must keep our eye on the role of neuroscientific information in his argument. Dehaene shows that young children's ability to count and invent efficient algorithms to solve simple addition and subtraction problems is quite remarkable. Mental calculations with larger numbers are another story; these are difficult not only for the young, but they also remain challenging for many adults: ''Clearly, the human brain … has not evolved for the purpose of formal calculation. This is why sophisticated arithmetic algorithms are so difficult for us to faithfully acquire and execute'' (*BL*, 289). Dehaene believes that children pay a high cost for the effort needed to commit multiplication tables and other facts to memory. They begin to find arithmetic dull and arid, and their intuitive sense of number atrophies instead of developing. Dehaene attributes children's difficulties in mathematics — revealed through psychologists' studies of errors children are liable to make — to the structure of the human brain:

> My hypothesis, then, is that innumeracy results from the difficulty of controlling the activation of arithmetic schemas distributed in multiple cerebral areas.… Innumeracy occurs because these multiple circuits often respond autonomously and in a disconnected fashion. Their arbitration, under the command of the prefrontal cortex, is often slow to emerge. (*BL*, 294)

What is to be done? Dehaene concludes that ''we cannot hope to alter the architecture of our brain, but we can perhaps adapt our teaching methods to the constraints of our biology'' (*BL*, 289). One solution to the problem is much greater use of the calculator: ''The calculator is like a road map for the number line. Give a calculator to a five-year old, and you will teach him how to make friends with numbers instead of despising them'' (*BL*, 290). Another solution, claims Dehaene, is a departure from the ''formalist vision of mathematics'' to a more concrete approach, with a focus on concrete materials. Here he cites Montessori's math teaching materials. Dehaene also favors a more applied focus, applying numbers to the solution of quantitative problems that children can grasp.

It is important to take note of the role of neuroscience in the foregoing argument. The evidence cited to substantiate the claim that large numbers of children are innumerate and to identify exactly where they fall short derives from the work not of neuroscientists, but of cognitive psychologists, even if the ultimate *explanation* for the pattern of limitations that they have identified lies in an understanding of the structure of the brain. This reinforces a general point made by John Bruer, a prominent skeptic of educational neuroscience, who argues in chapter 6, ''In Search of … Brain-Based Education,'' that ''whatever evidence we have for or against the efficacy of … educational approaches can be found in any current textbook on educational psychology. None of the evidence comes from brain research'' (*BL*, 52). None of the remedies proposed is new (for example, Montessori materials), nor do they depend in any way on evidence drawn from brain imaging. Indeed, Dehaene's passionate rejection of the way mathematics is taught in his own country must be seen not in light of any new evidence gleaned from neuroscience, but in the context of the extreme formalism that characterizes the traditional French curriculum, and this has everything to do with French educational and cultural practices and traditions and nothing to do with the brain.

Educational Philosophers on Neuroscience

Philosophers of education in the United Kingdom have, as I noted earlier, engaged with the new research on the brain and mind. Ruth Cigman, of the Institute of Education at the University of London, and Andrew Davis, of Durham University, have edited *New Philosophies of Learning*, a stimulating anthology that analyzes the new research in neuroscience and in psychology as well. The two editors have not only brought together a stimulating collection of essays but have also supplied an overview and review of the articles in each of the anthology's six sections.

Michael Oakeshott likened the diverse disciplines to diverse ''voices'' in a conversation, with no one voice dominating and each making its own contribution. Do we philosophers of education still have a distinctive voice, one that enhances the conversation about children and schooling, especially at a time in which those putative conversational partners in lab coats appear able to carry on quite well without us? The British anthology provides an opportunity to consider the question.

Do we need philosophers to tamp down the enthusiasm of neuroscientists who may be all too ready to launch bandwagons declaring that their research will show the way to the holy grail of educational transformation? The answer here is clear: we do not. In fact those at the new frontier are very aware of the limitations of their work and of the propensity of less skilled disciples to mislead the rest of us. Goswami devotes a section of her chapter to ''Avoiding the Seeding of Neuromyths.'' Indeed, she herself provides evidence that ''when physiological variables such as changes in brain activation are involved, it is easy to suspend one's critical faculties'' (*NPL*, 31). In articulating the principles of learning and their pedagogic implications, Goswami always inserts qualifying adverbs; for example, she maintains that ''the social nature of human learning means that learning with others is *usually* more effective than learning alone'' (*NPL*, 37, emphasis added).

Neuroscience may have the potential to identify the educational needs of diverse learners more securely. Do we need philosophers to ask such questions as ''Does Dyslexia Exist?'' the title of chapter 2.4 in *New Philosophies of Learning*? Again, apparently not. Here, educational *psychologists* Julian Elliott and Simon Gibbs demonstrate a clear grasp of the scientific and social-scientific literature on reading difficulties as well as the ethical and educational implications resulting from the use of such categories. They argue persuasively that ''the notion of dyslexia as a discrete, identifiable (*diagnosable*) condition that is held to pertain only for some, rather than all, with literary difficulties may obstruct inclusion and reduce overall educational attainment'' (*NPL*, 115, emphasis in original).

Where philosophers do appear to come into their own is in the unpacking of the broader conceptual framework that underlies the neuroscientific view of learning and education. In separate chapters, David Bakhurst and Paul Howard-Jones (chapters 1.5 and 1.2, respectively) do a commendable job of mapping this difficult terrain. Bakhurst contrasts two perspectives on the educational process: The perspective he favors foregrounds the person living in a historical culture, which he labels ''personalism''; the alternative perspective he calls ''brainism.'' Bakhurst's chapter is focused in part on a little-known Soviet philosopher, Evald Ilyenkov, who challenged the notion that the person could be identified with his or her brain. But Bakhurst brings to bear the work of contemporary philosophers, such as Peter Hacker and John McDowell, as well. Both Ilyenkov and McDowell, following Immanuel Kant, contend that in the course of their development from infancy, humans develop a ''responsiveness to reasons'' (*NPL*, 65) that sets them apart from the rest of the animal kingdom. Humans, unlike human brains, ''must be understood by appeal to rational, rather than merely causal-scientific, considerations'' (*NPL*, 66). What this means, ultimately, is not that brain science is irrelevant, argues Bakhurst, but that ''we must never lose sight of the wider communicative endeavor that is the heart of education: the meeting of minds in an encounter with a discipline'' (*NPL*, 69). Now while I think Bakhurst's chapter is exemplary, providing a helpful orientation to the relevant philosophical terrain, I doubt that neuroscientists such as Goswami believe that neuroscience alone can now or even in the future provide a blueprint for educators. For a chapter that provides not simply a philosophical overview from a considerable height above the terrain, but one that analyzes a key issue in such a way as to yield educational implications that matter, Andrew Davis's ''Ian Hacking, Learner Categories and Human Taxonomies'' demonstrates the *distinctive* contribution that philosophers of education can make.

Davis's strategy is to examine the parallel between learner categories and psychiatric disorder classifications since many scientifically oriented students of learning disorders attempt to borrow a medical approach. Davis's strategy enables him to draw on the insights of philosopher Ian Hacking, who himself follows Michel Foucault in formulating a crucial distinction between ''indifferent kinds'' and ''interactive kinds.'' With indifferent kinds, the substance classified is not conscious of its classification and its properties do not change as a result of that classification (the chemical elements provide the purest example). With interactive kinds, that which is classified is altered as a result of its classification. The ''ADHD child'' is treated differently and, more importantly, sees himself differently from the ''unruly child.'' The devisors of the ADHD label created, in effect, a new kind of child. However, according to Hacking, some psychiatric disorders, such as schizophrenias, ''have both indifferent kind *and* interactive kind characteristics'' (*NPL* 87, emphasis in original).

Now Davis examines whether those with a distinctive learning difficulty might share some distinctive essential feature, resulting from their condition being caused by an ''indifferent kind.'' Canvassing the relevant scientific literature in neuroscience, evolutionary biology, and genetics, Davis argues that this is exceedingly unlikely and, moreover, might not generate enhanced interventions for children given that diagnosis.

Finally, Davis traces the ethical and educational implications of his argument. Once a kind of behavior, such as the seeming inability to sit still or concentrate in class, has been ''medicalized,'' educators appear to be exempt from responsibility if students carrying a diagnosis like ADHD fail to learn. The upshot is this:

> I want to argue that the less a learner category can aspire to the status of an indifferent kind, the more the learners concerned should be regarded as belonging on a continuum with their fellow students, and treated accordingly. . . . There is no short, simple and coherent route from neuroscience alone to assertions that learner categories such as dyslexics and sufferers from ADHD in any sense ''mirror objective reality.'' (*NPL*, 95)

Now the reason I claim that Davis's chapter represents the distinctive voice of the philosopher of education is best seen by contrasting it with the chapter by Elliott and Gibbs discussed previously. Their conclusions are similar but Davis's position is both deeper and more nuanced. It is deeper because it examines the process of classification itself, whereas Elliott and Gibbs take it for granted. Davis is more nuanced in rejecting the dichotomy of characterizing things as either ''objective'' or ''socially constructed.'' Following Hacking, Davis acknowledges that some categorizations contain features of both.

It is important to note what Davis brings to bear in his chapter: an understanding of philosophical work addressing issues of classification, ranging from the work of Saul Kripke and Hillary Putnam to that of Hacking; a solid grasp of the scientific literature, including genetics and neuroscience as it relates to the problem; and an ability to apply this knowledge to an important educational issue so that we can see what is at stake and follow the argument.

Saying that I very much admire Davis's chapter is not the same thing as saying that I entirely agree with his conclusion; in fact, I don't. While Davis is right that teachers should not be relieved of responsibility when students who pose challenges fail to learn, neither should they be held responsible for failure that *does* legitimately derive from a student's inherent limitations — especially when those limitations are clearly grounded in biology. Taking a far-fetched example to make my point, even if parents of a son with Down syndrome were able to insist on enrolling him in a high school calculus class, it would be ludicrous to blame the teacher if the boy got nothing out of the class and failed the course.

Before returning to the relation between neuroscience and education, let me comment on a few chapters in part 2 of *New Philosophies of Learning*, entitled ''Learning and Human Flourishing.'' These chapters do not touch on the brain but are dependent on new research on human happiness. One subsection devotes three chapters to what it calls ''The Enhancement Agenda,'' which appears to have no precise parallel in the United States. Apparently in reaction to policies requiring an ever more intensive focus on test scores, the UK has instituted programs focused on mitigating the consequences of academic failure that inevitably accompany such policies, programs that emphasize self-esteem and happiness as defined and measured by influential social scientists such as Richard Layard. Each of the three authors contributing to this subsection — Ruth Cigman (chapter 4.2), Richard Smith (chapter 4.3), and Judith Suissa (chapter 4.4) — challenges these approaches.

I wish the editors had recruited a defender; I think the authors included here may overstate their case.

But among the three, I want to single out for praise Richard Smith's chapter ''The Long Slide to Happiness,'' a model of clarity and elegance of expression. Here, Smith does one of the other things that philosophers of education do best: subjecting a popular educational movement to critical scrutiny, finding it not simply lacking, but dangerous in its one-sidedness. The reason philosophers of education are especially suited to this genre (though they do not enjoy a monopoly here) is that such educational movements invariably depend on assumptions about concepts such as ''happiness'' to which philosophers have given sustained attention over generations.

Smith shows, to begin with, that happiness means a variety of different things to the different authors urging that schools focus on it, and these are not all consistent with each other. This leads to a critique of the social scientist Layard's attempt to reduce all kinds of happiness and unhappiness to points along a single continuum. Smith shows that social scientists err in thinking that one can simply score the *level* of happiness involved in some activity, such as sex, without understanding what the activity means to the participants, what role it plays in their lives. Next Smith shows not only that humans value all kinds of activities and projects that seem *not* to be motivated by the search for pleasure, but also that they knowingly court frustration and sacrifice in many cases. Drawing on an episode in Thomas Hughes's novel *Tom Brown's School Days*, Smith shows that a transformative moment in a classics class can bring a student to tears. In conclusion, Smith shows how the legitimate revulsion in response to an education system dominated by targets and testing ''risks being seduced by over-simplified conceptions of happiness as a matter of 'feeling good''' (*NPL*, 202), and thus leading to a restricted vision of what education and life can be. Let me observe here that in drawing amply from the visual arts and from literature, poetry especially, Smith appears to have been nurtured more by the arts than by the sciences. I believe this contributes to his retaining a sense of the essay as a genre that can exhibit not just a train of argument but a fine sense of craftsmanship, eliciting a reader's delight as well as his concurrence.

Let me return to neuroscience by way of Judith Suissa's chapter, ''Lessons from a New Science? On Teaching Happiness in Schools.'' Suissa offers a critique of ''positive psychology'' and its uses in education in the United Kingdom, covering some of the same ground as Smith, though without the stylistic virtues he displays. Borrowing from an earlier essay by Smith, Suissa decries the tendency among exponents of positive psychology to reduce living well, especially living ethically, to a set of skills or techniques. Suissa asks, ''Yet in what sense can forming and sustaining 'productive relationships' or 'caring for others' be described as 'skills'?'' If, she continues,

> happiness or well-being means something like 'living a worthwhile life' ... then to achieve this, surely one has to have some understanding of what it means to be human, what makes one's life worthwhile; what values one cherishes, and why. (*NPL*, 212)

Suissa has a solid philosophical point here, but the point does not carry her as far as she thinks it does. First of all, caring for others — children, for example — requires skills. Even doing something as basic as breastfeeding or diapering a baby requires skill and has to be learned. To this, Suissa might respond that the application of these skills presupposes a wish to satisfy the baby's hunger or relieve the discomfort of a wet diaper, which are not skills. This is no doubt true, so let me point to a more radical possibility, namely that an attitude of caring can be developed by developing certain skills, though not the skills involved in the caring itself. How might this be?

Neuropsychologist Richard Davidson and his students have been using brain imaging to study Buddhist monks who have devoted thousands of hours to meditative practices designed to reduce egocentrism and to foster loving-kindness and compassion, "the wish to relieve others' suffering."[4] Davidson has provided evidence that these monks do, indeed, feel more attuned to others' distress, and that novices who engage in similar practices for just one week show some of the benefits that prolonged immersion in meditation provides. Davidson and his colleagues have yet to show that this sensitivity translates into behavior consonant with a wish to relieve others' distress, but this is certainly plausible.

Now let us ask what role neuroscience is playing here. To Davidson and his colleagues, I'm sure the brain is key. The brain imaging studies provide the evidentiary link between the meditative practices and the increased sensitivity to the suffering of others. But suppose that the increased sensitivity to others' suffering resulting from meditative practice is not followed by an increase in altruistic actions. Then one might legitimately conclude that such meditative practices would have limited value in moral education programs. Suppose, on the other hand, that the meditative practices do (other things being equal, of course) increase the likelihood of practitioners undertaking actions to relieve the suffering of others, but that the brain imaging cannot detect any difference between those who meditate and those who do not. Here, the absence of a correlation between brain states and psychological states provides no reason to refrain from introducing meditation practices into moral education. The upshot, it appears, is that, *from the point of view of education*, neuroscientific information is not as critical as some who are infatuated with the new technology of brain imaging believe.

This brings us back to the relation between psychology, education, and neuroscience, the theme of Paul Howard-Jones's chapter. Howard-Jones, who teaches and conducts neuroscientific research at the University of Bristol, has a commendably sophisticated understanding of the philosophical issues and literature. He begins his chapter by showing that the neuroscientific understanding of learning and the understanding of learning common among teachers and educators bear no resemblance. This could support a dualist view in which neuroscience is considered simply irrelevant to the kinds of learning educators care about. Howard-Jones

4. Antoine Lutz et al., "Regulation of the Neural Circuitry of Emotion by Compassion Meditation: Effects of Meditative Expertise," *PLoS ONE* 3, no. 3 (2008): 1–10.

has some sympathy for this position but claims it carries too high a price: ignoring the compelling evidence for interaction between mind and brain:

> However, brain processes are clearly more than just a *reflection* of our mind's attempt to assign and contemplate meaning, since the suppression of brain processes . . . can reduce such mental abilities. Biological processes in the brain thus appear intimately bound up with our cognitive abilities, even if they cannot be considered as the same thing. (*NPL*, 15, emphasis in original)

Howard-Jones believes that mind and brain must be studied together, and he, along with others, favors the designation ''cognitive neuroscience'' for this project. One of the alleged benefits of attempting to take brain processes into account when studying educational development, as in studies of learning how to read, is that ''when biological and cognitive concepts of development resonate in this way, one can feel more confident about the validity of both'' (*NPL*, 19).

He recognizes that workers in this new field often privilege the impact of brain processes on overt behavior while ignoring the way behavior can alter the brain.[5] Howard-Jones also shows that the visual representations cognitive neuroscientists typically employ to display their understanding of the relation between the behavioral and brain levels make it appear that their investigations focus on an individual learner rather than on multiple individuals interacting with each other. Howard-Jones tries to at least partially remedy this by providing a diagram representing two individuals in communication.

Finally, Howard-Jones is commendably forthright about the limitations of brain research for learning in classrooms. Understanding such learning requires attentiveness to making and interpreting meaning in everyday social settings, and ''the difficulties in using current imaging technology to study everyday social interaction currently provides a barrier for neuroscientists approaching the sea of symbols'' (*NPL*, 20). He is no less aware of the tendency of previous students of development and education, from Jean Piaget to Jerome Bruner, to view biological development as providing constraints to learning rather than learning providing an impetus for development. Given Howard-Jones's very cautious view of the potential contribution of brain science to education in classrooms, one is left wondering what all the excitement is about.

How Neuroscience Matters for Education

Those working at the frontiers of neuroscience and learning have to act as cheerleaders for the new field without inflating its accomplishments to date. The fact that the pedagogic fruits of neuroscience are not yet ripe does not necessarily mean that the field's potential is limited. Let me consider two likely possibilities. Neither of these, I hasten to add, requires our entering the huge and contested terrain that philosophers have thoroughly traversed over the last quarter of a century concerning the ''in principle'' reducibility of psychology to neuroscience.

5. Davidson's research, mentioned previously, demonstrates how behavior [meditation] can change brain structures.

The first possibility is this: A fuller understanding of brain development may help us reinterpret phenomena that ''common sense'' is liable to misconstrue. Let me offer one illustration: The onset of adolescence typically brings changes in sleep patterns. Adolescents tend to stay up later at night and, if allowed to sleep, tend to wake up in mid-morning. Parents sometimes interpret this new pattern as laziness or resistance to going to school. A leading sleep researcher who has studied this phenomenon, Mary Carskadon, traces the change in adolescence to psychosocial factors that occur in combination with *biological* changes. She notes that ''it is not at all unlikely that teenagers are being asked to be awake when the circadian system is in its nocturnal mode. The students may be in school, but their brains are at home on their pillows.''[6] Let me be clear on this point: data from developmental neuroscience are not sufficient to *determine* policy concerning school start times, but they can and should legitimately inform it. In fact, some communities have responded to such information by starting high school an hour later.

The second possibility becomes evident when we look to such traditional fields as medicine, psychiatry, agriculture, and animal husbandry. The effectiveness of practitioners in all of these fields is normally evident to those who seek their services — a patient who regains her health, a customer who buys a flavorful peach, a farmer who purchases a cow that produces more milk. But the microprocesses that yield these results — the chemical and molecular mechanisms that produce them — are typically invisible and often mysterious, not only to those who benefit from them, but also to those who enlist them.

Consider one of these fields, agriculture: For millennia, farmers and plant breeders worked successfully to improve livestock and food crops using traditional methods of crossbreeding and selecting crops for desirable characteristics. In the last twenty years, however, these processes have been enhanced thanks to a deeper understanding of genetics; this has led to new techniques whereby individual genes can be transferred from one organism to another, enabling scientists to design new and improved plant and animal varieties. Take, for example, the introduction of Bt genes into corn plants. Corn is vulnerable to a variety of insects, and the bacterium Bacillus thuringiensis, which is found in the soil, is an effective and safe insecticide. Until about twenty years ago, farmers, including organic farmers, often used Bt sprays to prevent crop damage. Since then it has been possible to insert Bt genes into the corn plants, so that the plants themselves produce a substance that is toxic to insects but safe for humans.[7]

What lesson can we draw from the example? The main one is that the practical advances deriving from scientific discoveries at the micro level led to

6. Mary Carskadon, ''Factors Influencing Sleep Patterns of Adolescents,'' in *Adolescent Sleep Patterns: Biological, Social, and Psychological Influences*, ed. Mary Carskadon (Cambridge: Cambridge University Press, 2002), 19.

7. A.M. Shelton, ''What Is Bt and What Is the Risk of Insects Becoming Resistant to Bt Transgenic Plants?'' *Agricultural Biotechnology*; http://agribiotech.info/details/Shelton-Bt%20Mar%208%20-%2003.pdf.

novel interventions *at that level*. Note that the farmer does not create the Bt-engineered plant and needs little understanding of genetics and gene transfer technology. The task of producing the new corn seed is performed by those with entirely different kinds of training. This means that planting Bt corn is about the same as planting ordinary corn.

If we now transfer this lesson to education, it seems likely 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. Here, I repeat a point I made almost thirty years ago.[8] This point was echoed very recently by David Perkins: ''In the long term, the greatest contribution of neuroscience to learning may depend on action theories at the neural level.'' He adds that ''today, even when we can explain a deficit at the neural level, we cannot get in there and rewire the system. By and large, direct physical and chemical interventions are too crude to address underlying causes.''[9] This latter statement is not entirely correct. Cognitive enhancement with drugs is already widespread. Many college students and others who need to concentrate for long periods of time and do not have time to sleep make use of drugs typically prescribed for children with attention deficit hyperactivity syndrome. The use of such drugs to enhance concentration has received considerable attention, including a commentary in the prestigious science journal *Nature*.[10]

Beyond using existing drugs to enhance cognitive performance, neuroscientists, including Nobel Laureate Eric Kandel, are trying to design drugs that improve the ability to learn and to retain what is learned. This research exploits what Kandel and others have discovered concerning the molecular mechanisms of long-term memory. Some, like Kandel, are hoping that the new drugs will remedy cognitive deficits associated with some genetic disorders or other pathologies. Others are hoping that the increased understanding will lead to the ability to enhance learning and cognition of ''normal'' children and adults. Here, Perkins is right: we are talking about the future, not the present.[11] Another strand of research also holds great promise, though it may bear fruit only in decades. This research tries to identify pathways from genetic mutations to behavior disorders.[12] Other

8. Francis Schrag, ''Social Science and Social Practice,'' *Inquiry* 26, no. 1 (1983): 107–124.

9. David Perkins, ''On Grandmother Neurons and Grandfather Clocks,'' *Mind, Brain, and Education* 3, no. 3 (2009): 174.

10. Henry Greely et al., ''Towards Responsible Use of Cognitive-Enhancing Drugs by the Healthy,'' *Nature* 456, no. 7223 (2008): 702–705; http://dx.doi.org/10.1038/456702a.

11. Jonah Lehrer, ''Neuroscience: Small, Furry . . . and Smart,'' *Nature* 461 (2009): 862–864; http://www.nature.com/news/2009/091014/full/461862a.html.

12. Some headway has been made in dyslexia and in Williams syndrome. See Albert M. Galaburda et al., ''From Genes to Behavior in Development Dyslexia,'' *Nature Neuroscience* 9 (2006): 1213–1217, http://www.nature.com/neuro/journal/v9/n10/full/nn1772.html; and M.C. Gao et al., ''Intelligence in Williams Syndrome Is Related to STX1A, Which Encodes a Component of the Presynaptic SNARE Complex,'' *PLoS ONE* 5, no. 4 (2010): e10292, http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0010292.

geneticists are exploring the possibility of increasing ''normal'' intelligence by genetic means.

More relevant for educators, and more current rather than hoped for in the future, is the fact that some neuroscientists claim they can induce cognitive improvement through specialized training that does indeed ''rewire the system.'' The plasticity of the brain throughout life — a discovery of the neuroscientist Michael Merzenich in the 1980s — underlies this possibility. The work of Merzenich, Paula Tallal, and their collaborators deserves special mention here, though they are not the only neuroscientists following this path.

In the course of a lengthy interview with David Boulton, Merzenich says the following:

> I've been interested in developing strategies to use this incredibly powerful process of brain plasticity, the processes that underlie the evolution of functionality in a brain through learning and experience, to command them to control them, to master them, you could say; to drive correction in a brain so far that that's possible in a child that is impaired or an adult that is impaired. . . . So I've been very motivated to understand these processes on a level in which there could be some level of driving true correction — true neurological correction.[13]

This has led Merzenich and his collaborators to develop training software whose effectiveness, they claim, has been demonstrated in several rigorous trials.[14]

Educational Neuroscience; Or, Neuroscience for the Classroom

The developments I have sketched point educational neuroscience in a very different direction from that promoted by the leaders of the neuroscience and education movement, such as Fischer and Goswami. I envision ongoing research by cognitive neuroscientists yielding continued progress in understanding neural processes at the micro level, an understanding that will be translated into interventions designed to affect microlevel processes in order to reduce cognitive deficits and enhance performance at the macro level. Where will these interventions take place? Some might take place in the home, for example, computer games and exercises designed to remedy specific deficits or improve basic brain functions, as in the software products marketed by Posit Science, the company started by Merzenich and his colleagues. Some might take place in the pediatric clinic, and some in the preschool or school, but these would be ancillary to the school's mission, which would not be significantly affected by the introduction of these new possibilities.

To ensure that all children have access to those interventions that might help them, I can envision neuroscientific consultants attached to pediatric clinics, preschools, or elementary schools. They would function in much the way psychiatrists often do in mental health clinics, where they prescribe appropriate drugs that facilitate the work of ''talk'' therapists.

13. Michael M. Merzenich, ''Interview with David Boulton,'' http://www.childrenofthecode.org/interviews/merzenich.htm.

14. Paula Tallal et al., ''Language Comprehension in Language-Learning Impaired Children Improved with Acoustically Modified Speech,'' *Science* 271, no. 5245 (1996): 81–84.

In a recent manifesto, Goswami, Fischer, and others assert that ''a central challenge to educational neuroscience is how to bring educational insights into brain development and brain mechanisms into classrooms.''[15] It is precisely this equation of contributions to *education* with contributions to *learning in school classrooms* that I am here challenging. In closing, let me return to the conundrum mentioned at the outset and offer my resolution of it. Scientific advances in understanding the material basis of cognitive processes are indeed likely to enhance education in the future, but in my opinion, these advances are unlikely to affect classrooms or classroom teaching substantially — except, perhaps, by providing children who are more ready and more capable of learning.

15. Kurt W. Fischer, Usha Goswami, and John Geake, ''The Future of Educational Neuroscience,'' *Mind, Brain, and Education* 4, no. 2 (2010): 74.

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