Human Development

Letters to the Editor

Toward a Reasoned Approach to Neuroeducation in an Era of "Neuroeverything"

We are living in the era of "neuroeverything," including neuroaesthetics, neurolaw, and neurotheology. Compared to these far-flung interdisciplinary syntheses, neuroscience and education seem like an easy and obvious pair of disciplines to combine; human learning and development are central to education and are also active fields of research in neuroscience. Indeed, educator interest in neuroscience is high and now supports conferences, dozens of new books each year, and new commercial products aimed at educators.

Despite this widespread enthusiasm, the reality of neuroeducation is a mixed bag. As we have argued elsewhere [Hook & Farah, 2013], it is tempting to paint this new interdisciplinary field with a broad and critical brush. The scientific findings with substantive classroom applicability generally come from cognitive science, not neuroscience, and, when neuroscience is cited, it is primarily to validate commonsense practices such allowing children time to play and exercise at school. However, it is also true that many proponents of neuroeducation are appropriately cautious and skeptical [e.g., Ansari, De Smedt, & Grabner, 2012]. In addition, the promise of neuroeducation is beginning to be realized. There is a growing body of research with tremendous translational potential to improve education using new insights about the brain [e.g., Saygin et al., 2013].

What about the application of neuroscience to the education of children from poor families? What about its application to the policy, more generally, concerning poor children? Carol Lee [2014] offers a thoughtful and restrained critique of work on the neuroscience of poverty and its broader implications. She is not just concerned with the quality or relevance of the science, but with the ways in which it may encourage a new and counterproductive, even harmful, way of thinking about poor children and their needs.

Specifically, the "metanarrative" of neuroscience may promote ideas of the poor as a homogeneous group, marked by deficits that limit their life chances, independent of the quality of educational opportunity available to them. Professor Lee points out the problems with these ideas. To recapitulate a few here, poor children are individuals and the effects of poverty on a child will likely vary according to ethnic and cultural factors as well as global variations in geography and economy that drastically affect the nature of poverty itself. Not every psychological difference with respect to middle-class children can be assumed to be a deficit. And ongoing educational disadvantage cannot be ignored as a cause of reduced life chances. If neuroscience somehow leads us to overlook these facts, it will cause harm by encouraging us to stereotype, stigmatize, and give up on poor children.

We find little here to disagree with. But we also find little here to attribute to neuroscience per se, as opposed to any empirical attempt to study child development in poverty and its consequences for the child. Science is by nature step-by-step and cannot test all relevant factors simultaneously. Older and better-established approaches to studying child poverty may have gone further in assessing the generality of their theories, but there is nothing inherent in the neuroscience approach that is biased toward simplistic or "middle-class-centric" theories. Before elaborating on this point, we must first briefly characterize the goal of neuroscience in the area of childhood poverty.

Childhood experience and life outcomes are related by an arc of intertwined causal pathways which is both long-range and vastly complex. Neuroscience lets us study a causal way station in this arc, namely the brain, where the physical, psychological, and cultural forces impinging on the child shape the capabilities with which the child then faces life's developmental tasks at home, at school, and in the wider world. At its most modest, the rationale for applying neuroscience here is that the more different methods we bring to this daunting task the better. So, let neuroscience join the team! One might reasonably go a bit further and point out that neuroscience can also contribute some unique candidate mechanisms for understanding key phenomena. For example, stress regulation and memory consolidation share neural substrates, and parenting behavior in animals has been found to moderate the effects of stress hormones on these shared substrates. The linkage between stress, parenting behaviors, and learning would not be obvious from psychology or sociology, but it does follow from neuroscience [e.g., Farah et al., 2008; Hackman, Farah, & Meaney, 2010].

To return to the critique of the neuroscience of poverty, neuroscience will deliver true conclusions only if all appropriate factors are measured or controlled. For example, there may be cultural factors or other features of the child's life that powerfully moderate the effects of poverty. Similarly, we can arrive at correct conclusions from neuroscience only if we bear in mind important limitations and boundary conditions on the inferences that follow from a specific neuroscience

finding. For example, without assessing all types of language skill and reading instruction, we cannot draw blanket conclusions about them. Note that these are limitations of any single empirical study, neuroscientific or otherwise. Indeed, even where bodies of research are concerned, we cannot think of examples in human neuroscience or in education that fully rise to the standard of absoluteness and universality. However, psychology and education research has delivered reasonably clear and complete explanations of specific types of learning within a specific culture, and this is a standard to which our nascent field, the developmental neuroscience of poverty, can aspire. Achieving this will require long-term collaboration between neuroscientists and experts in child development. For this reason, we hope that Professor Lee will abandon the role of voyeur and take up the role of active contributor.

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References

- Ansari, D., De Smedt, B., & Grabner, R.H. (2012). Neuroeducation A critical overview of an emerging field. *Neuroethics*, *5*, 105–117.
- Farah, M.J., Betancourt, L., Shera, D.M., Savage, J.H., Giannetta, J.M., Brodsky, N.L., Malmud, E.K., Hurt, H. (2008). Environmental stimulation, parental nurturance and cognitive development in humans. *Developmental Science*, *15*, 793–801.
- Hackman, D.A., Farah, M.J., & Meaney, M.J. (2010). Socioeconomic status and the brain: Mechanistic insights from human and animal research. *Nature Reviews Neuroscience*, *11*, 651–659.
- Hook, C.J., & Farah, M.J. (2013). Neuroscience for educators: What are they seeking, and what are they finding? *Neuroethics, 6,* 331–341.

Lee, C.D. (2014). A voyeuristic view of possibilities and threats: Neurosciences and education. *Human Development, 57,* 1–4.

Saygin, Z.M., Norton, E.S., Osher, D.E., Beach, S.D., Cyr, A.B., Ozernov-Palchik, O., & Gabrieli, J.D. (2013). Tracking the roots of reading ability: White matter volume and integrity correlate with phonological awareness in prereading and early-reading kindergarten children. *The Journal of Neuroscience, 33,* 13251–13258.

Neurothreats and How to Prevent Them

In her helpful and timely commentary "A voyeuristic view of possibilities and threats: neuroscience and education," Dr. Carol Lee [2014] calls for a more collaborative and nuanced approach to neuroscience. Learning and development are messy – they are social processes interwoven within cultural contexts, involving willful actors with different prior experiences and desired outcomes. In contrast, the work of neuroscience often requires an exceptionally high degree of experimenter control to remove extraneous variability, sometimes even to the point of controlling for eye movements. In trying to intersect the worlds of education and neuroscience, Lee describes several potential threats. Three resonated with us especially, and we address them here by considering possible causes of these threats as a way to figure out how to move beyond them. One threat concerns issues of essentialism – as Lee says, "hierarchical assumptions of singular pathways through which optimal development occurs." The second, related threat involves concerns about overgeneralization of neuroscience findings to make broad judgments and prescriptions for education. The third threat involves normative assumptions about what is worth learning and for whom.

Essentialism

Essentialism refers to a type of explanation that presupposes that an entity or process depends on a singular set of necessary properties. Lee's concern is that neuroscience may convey the idea that there is a singular right way for the brain to behave. Any brains that do not behave that way are assumed (with their owners) to have a deficit. These deficit assumptions "become reified in institutional practices and in the distribution of societal resources" [Lee, 2014]. Such reified conclusions would fly in the face of substantial evidence that there is a great deal of successful variation, both between and within cultures, in what comprises a desirable outcome and how to achieve it.

One source of the essentialist threat is that neuroscience is predominantly a biological science not a social one, and it has a natural gravity towards explanations that identify what neural structures and processes are necessary to yield a given function. Moreover, when working at the intersection of biology and behavior, it is most tractable to start with tasks where there are gross performance differences, so it is possible to map between biological structure and behavioral function. For example, by studying differences between children who perform at regular levels on basic math tasks and those who perform at clinically low levels ("dyscalculics"), neuroscientists can identify brain regions that are recruited by the typically developing children but not the dyscalculics. For a young science, it is a reasonable strategy to link structural variation to behavioral variation on a single dimension (e.g., math ability, working memory ability, cognitive control). It can help map the functions of brain regions, and it may suggest remediation paths for children who exhibit severe struggles in important domains, such as math or reading.

As Lee notes, it is important to keep in mind that essentialist reasoning, which helps drive the science, can become a dangerous simplification. The predominant concern is that what seems necessary may only be one pathway to performance. Lee discusses one way to curtail the threat of essentialism, which is to increase the diversity of participants involved in neuroscience studies. A second way is to ensure a portfolio of research that includes studies that compare the effects of different instructional treatments on brain organization. In addition to highlighting the plasticity of the brain, this style of research is closer to the work of educators who try to orchestrate contexts to achieve agreed-upon learning outcomes. For example, in a classroom study, we had students learn integer addition through three instructional approaches that focused on different features of the integer number line. All approaches resulted in successful performance on basic computation, indicating that all three groups learned, but the instructional approaches were optimized for different kinds of problems. Looking at brain differences between these instructional approaches moves beyond essentialism. It fosters the idea that there may be multiple ways to achieve the same coarse goal, while also showing how different learning experiences lead to different patterns of activation in the brain that are more or less beneficial in different contexts.

Overgeneralization

The second threat brought out by Lee involves promiscuous generalizations that fabricate prescriptions for education. These prescriptions may be based on limited tasks and populations but carry weight because they are "brain-based." The fact that the expression "neuromyth" has made its way into the mainstream is some indication of the tendency to elaborate neuroscience findings well beyond the original context of the study to draw unwarranted implications. There are a flood of brain training programs that have come on the market, many of which are of questionable scientific background and value. Much the same as companies claim "eco-friendly" as a marketing ploy, many educational programs claim "brain-based."

Behavioral human neuroscience is a relatively new field made possible by non-invasive methods of recording brain structure and activity (e.g., fMRI). As such, it is making a first pass at trying to determine how different brain structures, and the connections between them, relate to human behavior. Imagine that a researcher wants to study the relation between memory and number in the brain by seeing how the brain changes as a child learns math facts. For the researcher getting started on this question, it does not matter very much how the math facts are taught as long as the child can produce the correct answer at the end. Unfortunately, whatever the teaching method, there

is the risk that the method could be proclaimed "brain based" if students exhibit changes based on the instruction, despite the fact that there was no comparison to another form of instruction.

In our experience, neuroscientists hate neuromyths and are often quick to point out flaws and overgeneralizations. The problem resides in the translation of the neuroscience findings, not the neuroscience or neuroscientists. A simple solution to this problem is to educate consumers of neuroscience claims. For instance, schools of education would do well to include a course on behavioral neuroscience that does not simply deliver packaged facts, but also includes discussions of methods and generalization. This way, educators would have a way to think about brain-based claims brought to the public by unwitting journalists and financially motivated enterprises.

Normative Assumptions

The goals of education and neuroscience are sympathetic, but come from fundamentally different perspectives. Education focuses on optimal conditions for learning. Much thought and discussion goes into what outcomes are most valuable – what is it we want students to learn, why, and for what contexts – as well as the best way of helping students achieve these outcomes while avoiding negative side effects. This is a normative endeavor, and it needs to be done with the realization that norms do not always travel across cultural boundaries. If brain patterns tied to a particular cultural experience (such as growing up in a middle-class US household) are taken as the default appropriate behaviors, this would be a very unhappy conclusion if one were to then observe that some people do not exhibit the "necessary" brain patterns.

In our experience, neuroscientists are happy for educators to tell them what is important, particularly if it involves vetted standardized measures that can be correlated with neural findings. A lot of faith is put in these measures, and the constructs being measured may be taken at face value because they have been vetted by education. For example, scale-based tests of math skill or language ability are taken as representing those abilities rather than digging into the measures to determine what specific constructs are being tested. This compartmentalized approach is more of a cooperation between neuroscience and education (you give us measures and instruction, and we will tell you what the brain is doing) rather than a collaboration in which both parties are determining the goals and questions together. This compartmentalization can lead to increased reification of (often problematic) standardized test outcomes at the expense of answering interesting new questions.

One way to overcome this threat is to have more true collaboration between education and neuroscience. In another work, we describe different models of what this collaboration might look like [Schwartz, Blair, & Tsang, 2012]. Lee points out interesting areas in which it might occur, such as at the intersection of cultural practices and brain processes. True interdisciplinary collaboration is

tremendously more difficult. Each contributor has a different vocabulary and a different lens through which they view the world. Coming to shared understandings and perspectives takes time, as does understanding the limitations and strengths of different research methods. Additionally, this kind of work requires negotiating not only what questions are asked about the brain, but fundamentally what outcomes are desired and why. For neuroscience to have implications for education that go beyond clinical populations, it may be worth the effort. Voyeurism is a good start. The next step is for educational researchers to figure out how to participate.

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References

- Lee, C. (2014). A voyeuristic view of possibilities and threats: Neurosciences and education. *Human Development*, 57, 1–4.
- Schwartz, D.L., Blair, K.P., & Tsang, J. (2012). How to build educational neuroscience: Two approaches with concrete instances. *British Journal of Educational Psychology Monograph Series*, *8*, 9–27.