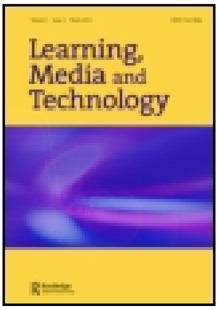

Learning, Media and Technology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/cjem20

No brain left behind: consequences of neuroscience discourse for education

Daniel S. Busso[a] & Courtney Pollack[a]
[a] Harvard Graduate School of Education, 13 Appian Way, Cambridge, MA 02138, USA
Published online: 22 Apr 2014.

Learning, Media and Technology, 2014
http://dx.doi.org/10.1080/17439884.2014.908908

No brain left behind: consequences of neuroscience discourse for education

Daniel S. Busso* and Courtney Pollack

Harvard Graduate School of Education, 13 Appian Way, Cambridge, MA 02138, USA

(*Received 29 October 2013; accepted 24 March 2014*)

Educational neuroscience represents a concerted interdisciplinary effort to bring the fields of cognitive science, neuroscience and education to bear on classroom practice. This article draws attention to the current and potential implications of importing biological ideas, language and imagery into education. By analysing examples of brain-based consumer products and services, we express a concern that neuroscience discourse can promote reductive and deterministic ways of understanding the developing child, masking phenomenological, psychosocial, or cultural influences. Moreover, a lack of neuroscience literacy and the appeal of neuroscience explanations may leave this field especially vulnerable to misunderstanding and misappropriation. We conclude by suggesting some opportunities to mitigate these problems, thereby facilitating constructive interdisciplinary dialogue.

Keywords: education; neuroscience; brain-based learning; neuroethics

Introduction

The emerging field of 'educational neuroscience' joins neuroscientists, psychologists, teachers and clinicians in building a scientific framework for education research and practice. This development is timely and important. Rapid progress in the biological sciences has catalysed new insights into brain function, child development and the neurological trajectories of typical and atypical development. Educational neuroscience (and its sister disciplines, 'mind, brain and education' and 'neuroeducation') provides an integrative framework that describes learning across multiple levels of analysis, from high-level phenomena (such as symbolic representations), to more granular, biological or molecular ones (neuronal function). In turn, these discoveries are fuelling hopes and expectations that this field can generate rigorous and actionable research that can impact the lives of students.

*Corresponding author. Email: dab393@mail.harvard.edu

There is little doubt that our knowledge of the developing brain is poised to make important contributions to the lives of parents, educators and policy-makers. Neuroimaging methods can contribute to more accurate identification for children at-risk for learning disabilities such as dyslexia (Gabrieli 2009; Hoeft et al. 2010) or explicate how biological processes can facilitate or hinder learning (Coch and Ansari 2012). As Shonkoff (2010) argues, neuroscience may provide the political impetus to prioritize early child-care programmes such as *Head Start*, based on knowledge of 'windows of opportunity' for brain development in the first few years of life. Yet, many have remained sober about the potential for neuroscience to transform the classroom: some have voiced concerns about the viability of educational neuroscience, suggesting that neuroscience can inform education only indirectly (Bruer 1997, 1998); others insist that neuroscience is only one small component of a multi-pronged research strategy to address educational challenges, rather than a panacea (Ansari and Coch 2006; Fischer et al. 2007). Still others highlight the unprecedented ethical dilemmas posed by research in the biological and brain sciences, particularly when brought to the political and social arena (Choudhury, Nagel, and Slaby 2009; Fukuyama 2003; Stein et al. 2011).

It is within this latter category – focusing on the ways in which culture, politics and society intersect with the biological sciences – that we situate this paper. We fully acknowledge the value of research initiatives that align biology, cognitive science, and child development. Yet, we also realise that excitement around educational neuroscience can be appropriated to serve dubious commercial or political ends, and consequently, the *ways* in which neuroscience has entered into educational spaces warrants careful examination. To progress responsibly, educational neuroscience will have to face difficult questions: what are the limitations of brain imaging and are they being communicated accurately? What does it mean to 'practice' brain-based education and how might this play out in schools? And finally, what are the ethical liabilities that surround educational neuroscience and how can we guard against them?

This paper is primarily concerned with the 'discourse' of educational neuroscience, which we define as the dispersal of neurobiological language, imagery, symbolism and rhetoric within formal and informal learning environments. We begin by surveying the educational neuroscience landscape, providing examples of brain-based consumer products and services and exploring the ways that they can be perceived (rightly or wrongly) as scientifically credible. Next, we consider the ways in which neuroscientific framing can have important theoretical and ethical implications for education: that it can essentialise types or groups of students; that it can privilege biological explanations for student learning (at the expense of others); and that it can raise important questions about the goals, purposes and values of education. Finally, we discuss potential solutions to safeguard against the misappropriation and misunderstanding of neuroscientific ideas.

The educational neuroscience landscape: brain-based curricula and products

Over the last decade, a wide array of brain-based commercial products and teaching guides has flooded the education market, claiming to be derived from or 'inspired' by neuroscience research [see Sylvan and Christodoulou (2010)]. The opportunities for neuroscience claims to permeate formal and informal education are vast, including through 'brain-training', professional development workshops and conferences, educational materials such as curricula and teaching guides, and psychoeducational assessment. We briefly review each in turn.

(1) 'Brain-Training', or the targeted improvement of isolated cognitive functions through practice, is one example of a neuro-educational product that represents a $300 million-a-year industry in the USA alone (Hurley 2012). Brain-training organizations (e.g., *LearningRx*, *CogMed*, and *Lumosity*) generally employ computerized tasks and use research on neuroplasticity to support their claim that their product 'changes the brain'. Companies typically assert that their product can strengthen key neurological pathways that support cognitive processes such as memory and attention, allowing students to learn faster and more efficiently.

(2) *Professional development workshops and conferences* also provide ample opportunities for education professionals to gain exposure – both credible and dubious – to educational neuroscience. Well-established educational research organizations in Europe (e.g., *European Association for Research on Learning and Instruction, The Royal Society*) and the USA (e.g., *American Educational Research Association*) have special interest groups that promote research in the field and disseminate findings to other researchers and practitioners, and several universities (e.g., Harvard University, University of Cambridge) provide graduate training in this field. Additionally, several for-profit organizations or educational entrepreneurs (e.g., *Learning and the Brain, Jensen Learning*) host workshops for practitioners or even certification programmes for future professional development leaders. These programmes typically focus on big ideas in neuroscience (e.g., neurogenesis, plasticity) or relate neuroscience to particular aspects of schooling (e.g., technology, attention deficit hyperactivity disorder (ADHD), reading).

(3) *Curricula or teaching guides* promote the use of brain-based or 'brain-centred' learning or teaching strategies (e.g., the *Brain Targeted Teaching*® Model, Hardiman 2012). Curricula or teaching guides may focus on neuroscience research and/or language to promote strategies for improving domain specific (e.g., *Fast ForWord*®) or domain-general (e.g., the *MindUP*® Curriculum) processes.

(4) *Psychoeducational assessors* may claim to use neuroimaging technology to diagnose or treat children and adolescents with a range of education-related difficulties, including speech and language disorders, learning disabilities and autism. Centres or clinics assert that the use of neurofeedback (e.g., *Center for Brain Training*, *Sterlingworth Center*), magnetic resonance imaging (e.g., *BrightMinds Institute*) or nuclear imaging (e.g., *Amen Clinics*) can aid in diagnosis or in the development of treatment plans.

Engagement with educational neuroscience

One commonly encountered concern is that neuroscience images and language are inordinately persuasive, leaving members of the public vulnerable to misunderstanding and misinformation (Uttal 2011). Several highly cited studies have shown that superfluous neuroscience information may bias the judgement of non-experts. For example, McCabe and Castel (2008) demonstrate that the perceived quality of neuroscience research is higher when accompanied by brain images. Similarly, non-experts have been shown to judge psychological explanations as more satisfying when they include logically irrelevant neuroscience information (Weisberg et al. 2008). In an educational context, Lindell and Kidd (2013) showed that participants given four advertisements for a hypothetical educational programme (either called 'Right Brain' or 'Right Start', and either with or without a brain image) rated the product as more interesting, more effective, and more scientifically rigorous in the presence of neuroscience language or imagery. Taken together, these experiments would suggest that neuroscience confers a sense of scientific legitimacy and explanatory depth that is not necessarily extended to explanations at the level of the mind or behaviour (Trout 2008).

However, the idea that neuroscience is uniquely persuasive has been met with little empirical support. Farah and Hook (2013) report that a number of studies failed to support this hypothesis. In addition, genetic explanations appear to hold their own appeal (Dar-Nimrod and Heine 2011), suggesting that this phenomenon may reflect a more general bias towards *scientific* explanations, rather than to neuroscience per se. Finally, it is possible that educational neuroscience may simply be newer and less familiar than other approaches. Faddism has been a long-standing problem in the educational sciences, and equally novel theoretical approaches may have also benefited from their own 'seductive allure' phase.

Nevertheless, excitement about neuroscience is concerning because it can be exploited by unscrupulous consumer–product manufacturers. The term 'brain-based' has been used to market an array of educational products, even if many examples of 'brain-based' pedagogy are neither derived from neuroscience, nor validated by it (Anderson and Della Sala 2012; Perkins 2009; Sylvan &

Christodoulou 2010). For example, brain-training organizations such as LearningRx (2013a) implore prospective customers to not 'settle for the brain you think you were born with' and that 'because the brain is always adapting and building, our ability to think, remember and learn is never static – it can always be upgraded and improved!'. These claims are superficially true, of course, but only insofar as every other kind of learning opportunity (including learning to ride a bike, watching Sesame Street or practicing the guitar) constitutes 'brain-training' also. Even ostensibly research-based educational strategies may use brain language inappropriately. Consider the 'neurological impress method' for reading (Flood, Lapp, and Fisher 2005), which Hruby (2012) describes as 'no more or less neurological than any other kind of educational method that makes an impression' (4). Such imprecise use of brain language may undermine legitimate efforts to meaningfully incorporate neuroscience into educational practice.

Compounding this problem is that most consumers, including parents and teachers, lack the requisite scientific knowledge to be able to distinguish between science and pseudoscience. Many educators rate brain-based products quite favourably, providing glowing testimonials for a product's effectiveness (Ritchie, Chudler, and Della Sala 2012). However, there are many reasons to ignore these claims, including that parents and teachers may be financially and emotionally invested in the success of the product, and that these anecdotes are handpicked by a commercially interested party. Moreover, the nuances of what constitutes scientific 'proof' are easy to misunderstand, especially by educators who are not intimately familiar with standards of scientific evidence and who may be dazzled by the neuroscience language and images on offer. To make matters worse, neuro-educational products can be expensive investments. An hour of one-to-one brain training can cost \$80–90, and one family of an ADHD student reportedly spent \$12,000 for one year of *LearningRx*'s help (Hurley 2012). Even if these educational products were available at low or no cost in schools, there is an opportunity cost involved. Time spent on solutions that focus on the brain translates into time not spent on other, potentially more effective interventions to ameliorate student difficulties.

Education through a neurobiological lens: theoretical and ethical considerations

We have suggested that neuroscience discourse is powerful, pervasive, and alluring, enjoying a scientific cachet that is not afforded to mental or behavioural levels of analysis. Why might this be the case? A simple answer may be that we live in a 'neuroculture' (Frazzetto and Anker 2009). Historians of science have argued that in modern, industrial societies, our understanding of the self – including beliefs, behaviours, and identity – is increasingly attributed to neurochemical processes (Ortega 2009; Vidal 2009). By adopting these biological vocabularies and narratives, we are encouraged to understand ourselves and our relationship with the world in very different ways: moral and ideological values are seen as adaptive or maladaptive brain states; complex notions about culture are being understood in neurochemical terms; even common sense notions of free will are being displaced. Indeed, language and metaphor are intimately related to our understanding of concepts and how we interact with the world, and can shape reasoning about complex social issues (Lakoff 2002; Lakoff and Johnson 1980; Thibodeau and Boroditsky 2013). How this biological framing plays out in education is something that we have only just begun to address.

Neuroscience discourse can reconfigure our identity as teachers, parents, or students, even reframing the way we understand the goals, purposes, and values of schooling. Here, we first explore the kinds of biases that might arise when differences between students are attributed to genes or neurobiology; what we term 'brain-typing'. Next, we highlight the issue of biological determinism, where human development is viewed through the lens of biology alone. Finally, we turn to a discussion on neuroethics in education: what does it mean to bring research to practice and where do values come into play? What are educational values and how might they be threatened by biological approaches to education?

'Brain-typing'

It is hard to miss the way that neuroscience language and imagery encourage us to categorize learners using apparent neurological differences. Examples abound in media articles, commercial products, and websites. Typically, brain images are juxtaposed to highlight neurological differences between groups, such as those with and without a learning disability. On their website, Reading Horizons (2013), an organization that provides teaching resources for K-12 reading instruction, presents literature on the neurological basis for dyslexia. Underneath two drawings of brains are the words 'dyslexic' and 'non-impaired'. Little scientific expertise is necessary to understand the intended message: individuals with and without reading disability hold qualitatively different *brain-types*. By placing these images side-by-side, there is a clear suggestion that neuroscientists can straightforwardly distinguish between dyslexics and non-dyslexics solely by their neural profile.

However, the notion that students (or more specifically, their brains) can be tidily grouped into categories such as 'typical' or 'atypical', 'dyslexic' or 'non-dyslexic', is fraught with scientific and ethical challenges. Clinical diagnoses often rest on disputed assumptions and contested criteria (Choudhury, Nagel, and Slaby 2009). Many authorities, including the US Department of Education (2013), use a discrepancy between IQ and a test of a certain educational skill (e.g., reading) to diagnose a child with a 'specific learning disability'. But this makes a diagnosis more likely for individuals with high intelligence and comparatively less likely for students with low intelligence (Butterworth and

Kovas 2013). Moreover, learning disabilities such as dyslexia or dyscalculia can be relatively heterogeneous, both at the level of brain and behaviour (Peterson, Pennington, and Olson 2013; Rubinsten and Henik 2009). Finally, mounting evidence suggests that what we describe as 'learning difficulties' are actually quantitative extremes of normal variability, rather than qualitatively distinct groups (Kovas and Plomin 2012). Together, these pictures paint a complex story about the characteristics of learning difficulties, and one that is not easily reducible to simplistic visual and verbal narratives about 'brain-types'. Indeed, scholars have critiqued theoretical approaches that focus on group averages, claiming that it masks the richness and pervasive variability of human development (Rose, Rouhani, and Fischer 2013).

To the extent that brain-typing affects the treatment of children within the education system, teachers and researchers must also consider the ethical implications of biological labelling, especially when these labels bear the stamp of scientific authority. To illustrate, consider autism. Early theories proposed that autism was mistakenly caused by poor, inattentive parenting (so-called 'refrigerator mothers'), leading to years of fruitless psychotherapy for affected children (Wolff 2004). In recent years, the cultural and clinical meaning of the term has shifted, with many researchers emphasizing the autistic phenotype as a symptom of neurocognitive difference rather than a pathology (Baron-Cohen 2002). Indeed, advocates of the neurodiversity (or 'autistic-rights') movement oppose a regimen of treatment, special education and exclusion, and instead suggest that the locus of the problem resides not within the individual, but with a society that is rigid and autism incompatible (Kapp et al. 2013). The meaning of clinical and educational labels is therefore powerfully intertwined with social norms, values, and the experiences of those diagnosed.

Consider also the idea that when categorical groupings are driven by putative 'biological' factors, those within a group appear homogenous and undifferentiated, and group differences appear large and insurmountable. Research shows that when groups are essentialised, they are represented as having deep, static, and unchanging properties (Prentice and Miller 2007). When these categories are a social group (e.g., racial, genetic, or neurobiological), individuals may perceive category members to share defining characteristics. For example, the more people see 'race' as a biological construct (rather than a socio-cultural one), the more accepting they are of discrimination against certain racial groups (Williams and Eberhardt 2008).

A further problem, as Hruby (2012) argues, is that biological essentialism has a lamentable history in the West

> where biological idioms have been recruited at times to reify social constructs of race, gender, and class as immutable natural phenomena, and to warrant the acceptance of disparities of power and social expectation on those bases as reasonable and natural. (16)

There is a risk that essentialising group differences – especially when these differences are couched in the scientifically authoritative language of brain science – can perpetuate, reinforce, and be used to justify social inequalities. Consider, *The Bell Curve* (Herrnstein and Murray 1996), a widely criticised book that asserted that inherited differences in intelligence were responsible for racial differences in achievement. The authors' claim rests on an assumption that race constitutes a biological construct, in spite of anthropological and scientific research to the contrary (Muntaner, Javier Nieto, and O'Campo 1996). The assumption that groups are biologically determined obscures the flexibility of diagnostic categories and their ability to change over time, and averts our gaze from the matrix of socio-cultural factors that help give rise to them. It is therefore concerning that the cause of other disparities in educational achievement could be shifted away from conversations regarding society and culture towards those attributing the cause to genes or 'brain-types'.

Reifying gender differences through brain-based narratives

A relevant example is the argument that putative 'hard-wired' differences between the brains of males and females justify single-sex classrooms or gender-specific teaching strategies. The work of Gurian (2006) and Gurian and Stevens (2007, 2010) is illustrative. In an article for a school-based journal (2006), he asserts that biology is the key driver for differences between school-aged males and females: girls are more verbose because they have greater blood flow in 'verbal areas' of the brain; they also have more emotional descriptions in their writing because they have 'more neural connections between the verbal centers and emotive centers in the limbic system' (126). In contrast, boys are fidgety because 'less of the calming chemical serotonin moves through the cerebral cortex' (126). Biology is presented as the only lens through which to understand gender differences in classroom behaviour and academic outcomes.

Of course, whether there are meaningful differences between male and female brains has been the subject of extensive scientific debate. Supporters of sex-differentiated education cite research, mostly derived from adult samples, that shows some degree of sexual dimorphism in the brain. Cortical volume is typically 8–10% higher in males than females, even when controlling for overall body mass or height (Giedd et al. 2012; Goldstein et al. 2001), and studies have shown that males and females show differential brain activation during certain cognitive tasks, particularly those related to visual, spatial, or verbal processing (Bell et al. 2006). Scholars posit that cognitive and behavioural differentiations of men and women may be genetically programmed through evolution (Wood and Eagly 2002) or that sex hormones such as testosterone drive men to be risky, aggressive, or libidinous (Coates and Herbert 2008).

However, there are also several notable critiques of this work (Fine 2012; Halpern et al. 2011; Vidal 2012). To begin with, boys' and girls' experiences are culturally differentiated from birth, and these socialization practices can mistakenly give rise to an illusion of biological innateness. Research shows, for example, that both parents and teachers convey implicit verbal and non-verbal signals about their different expectations for males and females, and these can shape development in ways consistent with stereotypical gender roles (Delk et al. 1986; Leinhardt, Seewald, and Engel 1979). Second, brain differences between males and females are often interpreted as being ingrained from birth and therefore immutable. But this fails to acknowledge that a snap-shot of an individual's brain at one moment in time does not address whether genetics or socio-cultural factors drove these differences to begin with (Vidal 2012). Third, there is no evidence that observed differences in brain structure and function correspond to any meaningful cognitive advantage in or outside the classroom. In fact, it is hypothesized that cortical density (number of neurons in a given volume) is greater in females than in males, such that it compensates cognitively for the effect of having an overall smaller brain volume (Willerman et al. 1992; Witelson, Glezer, and Kigar 1995). Together, this evidence suggests that a comprehensive understanding of gender necessitates multi-level explanations that span genetics, up through society and culture.

Gender is a sensitive educational topic, and rightly so. Sexism in schools is particularly insidious because it is channelled through hidden, gender-biased curricula, embedded within teacher–student interactions and sustained through inequitable opportunities for success (Sadker and Zittleman 2009). Yet, these institutional forces can be obscured by specious neuroscience explanations that construe gender differences as innate, static, and unavoidable: As Fine (2008) argues, this 'permits us to sit back and relax, with its seemingly neat explanation of our social structure and personal lives' (71). Accordingly, educational neuroscientists should realise that using neuroscience to guide decisions about gender in schools may, counter-intuitively, legitimize and sustain gender-based inequalities in the education system rather than address them.

Neuro-determinism and the biopsychosocial approach

Stein (2010) asks us to imagine a young child who is distractible and restless. Despite demonstrating knowledge of the class material, he struggles to perform academically; he begins to squabble with peers and enters into aggressive confrontations with his teachers. What are we to do? Stein offers a number of possibilities. We might look to the boy's brain to determine whether a neurological condition may give rise to these behaviours, or look to other aspects of biology such as sleeping habits or exercise. We might seek first-person reports to better understand the child's feelings and motivations. We might look to social and cultural contexts: to the practices and policies of the school, the boy's relationships with adults and the pedagogy used in the classroom. Ultimately, the answer is that only a comprehensive picture of the student – one that considers biological, psychological, and socio-cultural factors in tandem – will yield usable knowledge for educators. This framework is typically referred to as the 'whole-child' or 'biopsychosocial' approach (Fischer 2009; Rappolt-Schlichtmann, Ayoub, and Gravel 2009), and has been offered as a meta-theory to guide work in educational neuroscience.

Yet, many brain-based services fail to replicate this disciplinary blend, instead privileging biology whilst eschewing phenomenological, cognitive, or socio-cultural perspectives. *Amen Clinics* offers help to children and adults with memory problems, autism, and learning problems, amongst others. Their website seemingly reduces every problem to faulty neural wiring, claiming that by examining brain images, '[doctors] are able to see what is working and what isn't. From this, diagnosing and treating a mental disturbance goes from guesswork to pure science' (Amen Clinics 2013). LearningRx (2013b), an educationally oriented company, espouses to help everyone learn faster and easier, including students with dyslexia, autism, and ADHD. They tout brain training as 'the key to enhanced learning', through the 'rapid strengthening and growth of ... neuronal connections' (LearningRx, 2013c). A final example is Jensen's (2014) line of Brain-Based Workshops, including 'Enriching the Brains of Students In Poverty,' which explains 'four ways the brains of kids from poverty are physically different' and offers appropriate teaching strategies.

The deterministic nature of these claims eclipses more nuanced, holistic explanations of individuals' experiences. How might this relate to education in schools? A focus on the brain may obstruct other ways of assessing student difficulties. For instance, factors such as emotional experiences (Immordino-Yang 2013), teacher–student relationships (Beilock et al. 2010), social context and stress (Rappolt-Schlichtmann, Ayoub, and Gravel 2009), and stereotype threat (Adams et al. 2006; Beilock et al. 2006) may contribute to learning challenges; none can necessarily be reduced to biology alone. A disregard for such factors may in fact delay or prohibit educators from accurately diagnosing the source of student difficulty.

Finally, it is possible that biological framing in education may reconfigure the ways that students understand themselves and their actions. An on-going debate in neuroscience concerns the implications of brain research for understanding human agency and personal responsibility (Greene and Cohen 2004). Separate from whether free will actually exists, however, is whether our *belief* in free will matters. Educators and students rely on the notion that growth is possible, and that student difficulties can, to some degree, be remediated through personal effort. In some cases, belief in biological determinism may free educators from making value judgements about the challenges their students face (e.g., by attributing responsibility to external factors such as faulty neuronal wiring). However, it may also relocate *students*' sense of their own personal responsibility. When studies prime individuals to disbelieve in free will [e.g., telling them that 'all behaviour is determined by brain activity, which is in turn determined by a combination of genetic and environmental factors' (262)], they are more likely to behave in impulsive, selfish, and even aggressive ways (Baumeister, Masicampo, and DeWall 2009). Similar deterministic primes have increased the likelihood of students cheating on a task (Vohs and Schooler 2008). Accordingly, by locating explanations for student behaviour 'in the brain', we may be depriving them of responsibility and control over their actions.

Educational neuroethics

As educators and researchers, it is easy to believe that because we learn that the brain functions develop in a particular way, we must unquestioningly redesign our schools and classrooms. However, schooling is an inherently value-laden enterprise, and educational decision-making – from classroom pedagogy through to policy – reflects assumptions about the skills and knowledge that we deem to be culturally important (Sheridan, Zinchenko, and Gardner 2005). To return to a previous example: should we frame autism as a neurological deficit or a neurological difference? Having knowledge of compensatory strategies that would allow us (in theory) to 'remediate' the symptoms of autism does not indicate whether this is something we *should* do. As discussed above, many autistic individuals view their condition positively and oppose attempts to find a cure (Kapp et al. 2013). While scientific consensus can often discriminate between 'good' and 'bad' research, how to excavate the ethical implications of educational and political decision-making is even less clear.

Educational neuroscience also surfaces important questions about the goals, values, and purposes of education. Looking to philosophy, Dewey (1916) once described education as providing the 'social continuity of life', and others have emphasized students' roles in serving the beliefs, knowledge, and values of society (Counts 1978) or cultivating intellect, creativity, and purpose (Rogers 1994). Amidst these ideals, one may be underwhelmed by Szűcs and Goswami (2007), who state that 'education involves the shaping of individual brains via targeted experience in the classroom' (114). Naturally, changes to the brain are preconditions for learning to occur. But brain-changes and education are not coterminous. To say that a teacher (in the fullest sense of the word) is a kind of social stimulus acting upon regions of a student's brain presents an impoverished view of what really goes on in classrooms. Teachers can inspire, empower, and engage *individuals*, not just their brains, not only inviting them to have experiences but to reflect on them too, nurturing their moral sensibilities and fostering their aesthetic preferences. We are a long way from understanding these processes at the level of the brain, if ever we can. Indeed, this reduction of education to neurological 'tinkering' tends to neglect the social, cultural, and interpersonal dimensions of schooling. In turn, this constrained view may cause teachers to privilege so-called brain-based educational strategies and methods (cognitive skills training, rote learning, and even psychopharmacology) at the expense of others (cooperative learning, moral education, and critical pedagogy).

Finally, we draw attention to the possibility that educational neuroscience can subtly reconstitute the duty of care between parent and child, teacher and student, and school and family. Applying Kant's categorical imperative, Stein (2010) makes the ethical distinction between *designing* children and *raising* them: the former referring to practices that alter a child's behaviours and dispositions through physical and instrumental means, such as via neurochemical enhancement; the latter referring to strategies that aim to care for children rather than fix them, acknowledging the importance of cooperation and shared language and values. Farah (2005) posits a similar view, stating that brain enhancement strategies can erode 'the metaphysical distinction … between things (even complex biophysical things) and persons' (37). For educational neuroscience to progress responsibly, we need to carefully demarcate the ethical boundaries that guide educational decision-making.

Educational neuroscience: future considerations

The interdisciplinary partnership of neuroscience and education presents exciting opportunities to help build a scientific groundwork for education practice and policy. Studies reveal a high level of enthusiasm for neuroscience among teachers (Pickering and Howard-Jones 2007), and this enthusiasm can be effectively harnessed in service of building better learning environments for children. Yet powerful, often self-interested, commercial forces serve as mediators between research and practice, and this raises some pressing questions for future work in the field: what does responsible translation look like? How can we create new forms of infrastructure that relay scientific knowledge effectively? Although comprehensive answers to these questions are beyond the scope of this paper, our analysis suggests that careful and selective use of neuroscience verbiage may help guard against misappropriation and misunderstanding.

There is also a need to teach non-scientists to think critically and sceptically about neuroscience research and the related products and services they may encounter. There is generally a low level of neuroscience literacy among the public, and while many understand that brain and behaviour are related, a common belief is that certain skills are biologically hardwired and therefore not amenable to educational influence. In a survey of college-educated adults in Brazil, the public generally did not equate learning with modifications in the brain, and 53% of respondents believed that 'mental practice did not improve performance' (Herculano-Houzel 2002). In addition, only just under 50% of British teacher trainees disagreed with the statement 'learning problems associated with developmental differences in brain function cannot be remediated through education' (Howard-Jones et al. 2009). For teachers working with children in their care, these data are troubling. One remedy may be to highlight the intricate and complex interplay between genetic, neurobiological and environment factors, thereby undermining this deterministic mindset (Dar-Nimrod and Heine 2011). Another may be to train teachers and parents to more effectively assess the quality of evidence for scientific claims.

Relatedly, we advocate for discussions concerning *what* neuroscience content is important, to *whom* it should be communicated, and *how* it should be translated. What do teachers want and need to know? Research suggests that teachers have a curiosity about the brain and the field of neuroeducation (Hook and Farah 2013), and recent efforts have attempted to distil neuroscience research to inform teacher professional development (Dubinsky, Roehrig, and Varma 2013). Yet, the education landscape resembles an unfettered marketplace and it is often difficult for teachers and parents to discriminate between the good, the bad, and the ugly (Anderson and Della Sala 2012). Moreover, besides a relative few (e.g., Institute of Education Sciences in the USA, University of York Institute for Effective Education in the UK), there is a dearth of reputable clearinghouses to distinguish between science and pseudoscience, leaving interested educators to fend for themselves. We also suggest a need for a communications consortium that can explicitly focus on issues relating to the translation of educational neuroscience research to the broader education community. Shonkoff and Bales (2011) offer a useful model in which to develop, test, and refine simplifying models to explain complex scientific concepts about child development to non-scientists. This type of communications work could develop in parallel with neuroscience research itself.

We suggest a need to build better connections between neuroscience researchers and practitioners in classrooms (Coch et al. 2009). Educational neuroscience research and conceptual frameworks fill the pages of academic journals, but opportunities for dialogue between teachers and researchers are still relatively scarce. In some cases, researchers attend practitioner-oriented conferences (e.g., *Learning and the Brain*) or produce for-teacher curriculum materials (Hardiman 2012). Some have called for 'research schools' as a form of infrastructure that can bridge the worlds of research and practice (Hinton and Fischer, 2008). In turn, this may leave less room for misunderstandings about neuroscience and the products that exploit them.

Finally, we also highlight the ethical liabilities posed by discourse in educational neuroscience and suggest these warrant attention. Language and imagery play an important role in the way we think and reason (Lakoff and Johnson 1980). The neurobiological framing of education may inadvertently lead us to essentialise types of students, which may obscure complex explanations for student behaviours or downplay students' sense of agency. In turn, neurobiological framing could alter the basic values and goals that drive education, such that the current notion of brain-based teaching methods may displace or bypass, rather than integrate with, teaching methods that focus on behaviour, relationships, culture, or psychosocial factors. Moving forward, educational neuroscience will be best served by a greater consideration of these ethical debates.

Acknowledgements

We would like to thank Dr Gigi Luk and two anonymous reviewers for their thoughtful comments on previous versions of this manuscript.

Notes on contributors

Daniel Busso is a doctoral student at the Harvard Graduate School of Education, where he studies the impact of early adversity (maltreatment, trauma, and poverty) on developmental, educational, and mental health outcomes in children. More broadly, he is interested in using the tools of neurobiology and cognitive science to better address questions of educational practice and policy.

Courtney Pollack is a doctoral student at the Harvard Graduate School of Education. Her primary research interests concern mental and neural representations of quantity as they relate to mathematical variables. Her other interests include mathematics difficulties, college-level math remediation, and issues in mind, brain, and education.

References

Adams, Glenn, Donna M. Garcia, Valerie Purdie-Vaughns, and Claude M. Steele. 2006. "The Detrimental Effects of a Suggestion of Sexism in an Instruction Situation." *Journal of Experimental Social Psychology* 42 (5): 602–615. doi:10.1016/j.jesp.2005.10.004.

Amen Clinics. 2013. "Real People, Real Outcomes." Accessed September 4, 2013. http://www.amenclinics.com/outcome-study

Anderson, Mike, and Sergio Della Sala. 2012. "Neuroscience in Education: An (opinionated) Introduction." In *Neuroscience in Education: The Good, The Bad and The Ugly*, edited by S. Della Sala and M. Anderson, 3–12. Oxford: Oxford University Press.

Ansari, Daniel, and Donna Coch. 2006. "Bridges over Troubled Waters: Education and Cognitive Neuroscience." *Trends in Cognitive Sciences* 10 (4): 146–151. doi:10.1016/j.tics.2006.02.007.

Baron-Cohen, Simon. 2002. "The Extreme Male Brain Theory of Autism." *Trends in Cognitive Sciences* 6 (6): 248–254. doi:10.1016/S1364-6613(02)01904-6.

Baumeister, Roy F., E. J. Masicampo, and C. Nathan DeWall. 2009. "Prosocial Benefits of Feeling Free: Disbelief in Free Will Increases Aggression and Reduces Helpfulness." *Personality and Social Psychology Bulletin* 35 (2): 260–268. doi:10.1177/0146167208327217.

Beilock, Sian L., Elizabeth A. Gunderson, Gerardo Ramirez, and Susan C. Levine. 2010. "Female Teachers' Math Anxiety Affects Girls' Math Achievement." *Proceedings of the National Academy of Sciences* 107 (5): 1860–1863. doi:10.1073/pnas.0910967107.

Beilock, Sian L., William A. Jellison, Robert J. Rydell, Allen R. McConnell, and Thomas H. Carr. 2006. "On the Causal Mechanisms of Stereotype Threat: Can

Skills That Don't Rely Heavily on Working Memory Still be Threatened?" *Personality and Social Psychology Bulletin* 32 (8): 1059–1071. doi:10.1177/0146167206288489.

Bell, Emily C., Morgan C. Willson, Alan H. Wilman, Sanjay Dave, and Peter H. Silverstone. 2006. "Males and Females Differ in Brain Activation During Cognitive Tasks." *NeuroImage* 30 (2): 529–538. doi:10.1016/j.neuroimage.2005.09.049.

Bruer, John T. 1997. "Education and the Brain: A Bridge Too Far." *Educational Researcher* 26 (8): 4–16. doi:10.3102/0013189X026008004.

Bruer, John T. 1998. "Brain Science, Brain Fiction." *Educational Leadership* 56 (3): 14–18.

Butterworth, Brian, and Yulia Kovas. 2013. "Understanding Neurocognitive Developmental Disorders Can Improve Education for All." *Science* 340 (6130) (April 19): 300–305. doi:10.1126/science.1231022.

Choudhury, Suparna, Saskia Kathi Nagel, and Jan Slaby. 2009. "Critical Neuroscience: Linking Neuroscience and Society Through Critical Practice." *BioSocieties* 4 (1): 61–77. doi:10.1017/S1745855209006437.

Coates, J. M., and J. Herbert. 2008. "Endogenous Steroids and Financial Risk Taking on a London Trading Floor." *Proceedings of the National Academy of Sciences* 105 (16) (April 22): 6167–6172. doi:10.1073/pnas.0704025105.

Coch, Donna, and Daniel Ansari. 2012. "Constructing Connection: The Evolving Field of Mind, Brain and Education." In *Neuroscience in Education: The Good, The Bad and The Ugly*, edited by S. Della Sala and M. Anderson, 33–46. Oxford: Oxford University Press.

Coch, Donna, Stephen A. Michlovitz, Daniel Ansari, and Abigail Baird. 2009. "Building Mind, Brain, and Education Connections: The View from the Upper Valley." *Mind, Brain, and Education* 3 (1): 27–33. doi:10.1111/j.1751-228X.2008.01050.x.

Counts, George S. 1978. *Dare the School Build a New Social Order?* Carbondale: Southern Illinois University Press.

Dar-Nimrod, Ilan, and Steven J. Heine. 2011. "Genetic Essentialism: On the Deceptive Determinism of DNA." *Psychological Bulletin* 137 (5): 800–818. doi:10.1037/a0021860.

Delk, John L., R. Burt Madden, Mary Livingston, and Timothy T. Ryan. 1986. "Adult Perceptions of the Infant as a Function of Gender Labeling and Observer Gender." *Sex Roles* 15 (9–10): 527–534. doi:10.1007/BF00288229.

Dewey, John. 1916. *Democracy and Education*. New York: Macmillan.

Dubinsky, J. M., G. Roehrig, and S. Varma. 2013. "Infusing Neuroscience into Teacher Professional Development." *Educational Researcher* 42 (6): 317–29. doi:10.3102/0013189X13499403.

Farah, Martha J. 2005. "Neuroethics: The Practical and the Philosophical." *Trends in Cognitive Sciences* 9 (1): 34–40. doi:10.1016/j.tics.2004.12.001.

Farah, Martha J., and Cayce J. Hook. 2013. "The Seductive Allure of 'Seductive Allure'." *Perspectives on Psychological Science* 8 (1): 88–90. doi:10.1177/1745691612469035.

Fine, Cordelia. 2008. "Will Working Mothers' Brains Explode? The Popular New Genre of Neurosexism." *Neuroethics* 1 (1): 69–72. doi:10.1007/s12152-007-9004-2.

Fine, Cordelia. 2012. "Explaining, or Sustaining, the Status Quo? The Potentially Self-Fulfilling Effects of 'Hardwired' Accounts of Sex Differences." *Neuroethics* 5 (3): 285–294. doi:10.1007/s12152-011-9118-4.

Fischer, Kurt W. 2009. "Mind, Brain, and Education: Building a Scientific Groundwork for Learning and Teaching1." *Mind, Brain, and Education* 3 (1): 3–16. doi:10.1111/j.1751-228X.2008.01048.x.
Fischer, Kurt W., David B. Daniel, Mary Helen Immordino-Yang, Elsbeth Stern, Antonio Battro, and Hideaki Koizumi. 2007. "Why Mind, Brain, and Education? Why Now?" *Mind, Brain, and Education* 1 (1): 1–2. doi:10.1111/j.1751-228X.2007.00006.x.
Flood, James, Diane Lapp, and Douglas Fisher. 2005. "Neurological Impress Method PLUS." *Reading Psychology* 26 (2): 147–160. doi:10.1080/02702710590930500.
Frazzetto, Giovanni, and Suzanne Anker. 2009. "Neuroculture." *Nature Reviews Neuroscience* 10 (11): 815–821. doi:10.1038/nrn2736.
Fukuyama, Francis. 2003. *Our Posthuman Future: Consequences of the Biotechnology Revolution*. New York: Picador.
Gabrieli, John D. E. 2009. "Dyslexia: A New Synergy Between Education and Cognitive Neuroscience." *Science* 325 (5938): 280–283. doi:10.1126/science.1171999.
Giedd, J. N., A. Raznahan, K. L. Mills, and R. K. Lenroot. 2012. "Review: Magnetic Resonance Imaging of Male/Female Differences in Human Adolescent Brain Anatomy." *Biology of Sex Differences* 3 (1): 19. doi:10.1186/2042-6410-3-19.
Goldstein, Jill M., Larry J. Seidman, Nicholas J. Horton, Nikos Makris, David N. Kennedy, Verne S. Caviness, Stephen V. Faraone, and Ming T. Tsuang. 2001. "Normal Sexual Dimorphism of the Adult Human Brain Assessed by In Vivo Magnetic Resonance Imaging." *Cerebral Cortex* 11 (6): 490–497. doi:10.1093/cercor/11.6.490.
Greene, Joshua, and Jonathan Cohen. 2004. "For the Law, Neuroscience Changes Nothing and Everything." *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences* 359 (1451): 1775–85. doi:10.1098/rstb.2004.1546.
Gurian, Michael. 2006. "Learning and Gender." *American School Board Journal* 193 (10). http://www.uwplatt.edu/library/ereserves/Learning_And_Gender.pdf
Gurian, Michael, and Kathy Stevens. 2007. *The Minds of Boys: Saving Our Sons From Falling Behind in School and Life*. Reprint ed. San Francisco: Jossey-Bass.
Gurian, Michael, and Kathy Stevens. 2010. *Boys and Girls Learn Differently! A Guide for Teachers and Parents*. Revised 10th Anniversary Edition. Jossey-Bass.
Halpern, Diane F., Lise Eliot, Rebecca S. Bigler, Richard A. Fabes, Laura D. Hanish, Janet Hyde, Lynn S. Liben, and Carol Lynn Martin. 2011. "The Pseudoscience of Single-Sex Schooling." *Science* 333 (6050): 1706–1707. doi:10.1126/science.1205031.
Hardiman, Mariale M. 2012. *The Brain-Targeted Teaching Model for 21st-Century Schools*. Thousand Oaks: Corwin.
Herculano-Houzel, Suzana. 2002. "Do You Know Your Brain? A Survey on Public Neuroscience Literacy at the Closing of the Decade of the Brain." *The Neuroscientist: A Review Journal Bringing Neurobiology, Neurology and Psychiatry* 8 (2): 98–110.
Herrnstein, Richard J., and Charles Murray. 1996. *Bell Curve: Intelligence and Class Structure in American Life*. 1st Free Press pbk. ed. New York: Simon & Schuster.
Hinton, Christina, and Kurt W. Fischer. 2008. "Research Schools: Grounding Research in Educational Practice." *Mind, Brain, and Education* 2 (4): 157–160. doi:10.1111/j.1751-228X.2008.00048.x.
Hoeft, Fumiko, Bruce D. McCandliss, Jessica M. Black, Alexander Gantman, Nahal Zakerani, Charles Hulme, Heikki Lyytinen, et al. 2010. "Neural Systems

Predicting Long-term Outcome in Dyslexia." *Proceedings of the National Academy of Sciences* 108 (1): 361–366. doi:10.1073/pnas.1008950108.
Hook, Cayce J., and Martha J. Farah. 2013. "Neuroscience for Educators: What Are They Seeking, and What Are They Finding?." *Neuroethics* 6 (2): 331–341. doi:10.1007/s12152-012-9159-3.
Howard-Jones, Paul, Lorna Franey, Rasha Mashmoushi, and Yen-Chun Liao. 2009. "The Neuroscience Literacy of Trainee Teachers." In University of Manchester. http://70.33.241.170/~neuro647/wp-content/uploads/2012/03/Literacy.pdf
Hruby, George G. 2012. "Three Requirements for Justifying an Educational Neuroscience." *British Journal of Educational Psychology* 82 (1): 1–23. doi:10.1111/j.2044-8279.2012.02068.x.
Hurley, Dan. 2012. "A New Kind of Tutoring Aims to Make Students Smarter." *The New York Times*, October 31, sec. Education/Education Life. http://www.nytimes.com/2012/11/04/education/edlife/a-new-kind-of-tutoring-aims-to-make-students-smarter.html
Immordino-Yang, Mary Helen. 2013. "Emotions, Social Relationships, and the Brain: Implications for the Classroom." *ASCD Express*. http://www.ascd.org/ascd_express/vol3/320_immordino-yang.aspx
Jensen Learning. 2014. "Enriching the Brains of Students in Poverty." Accessed February 21, 2014. http://www.jensenlearning.com/products.php
Kapp, Steven K., Kristen Gillespie-Lynch, Lauren E. Sherman, and Ted Hutman. 2013. "Deficit, Difference, or Both? Autism and Neurodiversity." *Developmental Psychology* 49 (1): 59–71. doi:10.1037/a0028353.
Kovas, Yulia, and Robert Plomin. 2012. "Genetics and Genomics: Good, Bad and Ugly." In *Neuroscience in Education: The Good, The Bad and The Ugly*, edited by S. Della Sala and M. Anderson, 155–173. Oxford: Oxford University Press.
Lakoff, George. 2002. *Moral Politics: How Liberals and Conservatives Think*. 2nd ed. Chicago: University of Chicago Press.
Lakoff, George, and Mark Johnson. 1980. *Metaphors We Live By*. Chicago: University of Chicago Press.
LearningRx. 2013a. "Brain Training 101." Accessed February 21, 2014. http://www.learningrx.com/brain-training-101.htm
LearningRx. 2013b. "Who Can We Help?" Accessed February 21, 2014. http://www.learningrx.com/brain-training-help.htm
LearningRx. 2013c. "What is Brain Training?" Accessed February 21, 2014. http://www.learningrx.com/what-is-brain-training.htm
Leinhardt, Gaea, Andrea M. Seewald, and Mary Engel. 1979. "Learning What's Taught: Sex Differences in Instruction." *Journal of Educational Psychology* 71 (4): 432–439. doi:10.1037/0022-0663.71.4.432.
Lindell, Annukka K., and Evan Kidd. 2013. "Consumers Favor 'Right Brain' Training: The Dangerous Lure of Neuromarketing." *Mind, Brain, and Education* 7 (1): 35–39. doi:10.1111/mbe.12005.
McCabe, David P., and Alan D. Castel. 2008. "Seeing Is Believing: The Effect of Brain Images on Judgments of Scientific Reasoning." *Cognition* 107 (1): 343–352. doi:10.1016/j.cognition.2007.07.017.
Muntaner, Carles, F. Javier Nieto, and Patricia O'Campo. 1996. "The Bell Curve: On Race, Social Class, and Epidemiologic Research." *American Journal of Epidemiology* 144 (6): 531–536.
Ortega, Francisco. 2009. "The Cerebral Subject and the Challenge of Neurodiversity." *BioSocieties* 4 (4): 425–445. doi:10.1017/S1745855209990287.

Perkins, David. 2009. "On Grandmother Neurons and Grandfather Clocks." *Mind, Brain, and Education* 3 (3): 170–175. doi:10.1111/j.1751-228X.2009.01067.x.

Peterson, Robin L., Bruce F. Pennington, and Richard K. Olson. 2013. "Subtypes of Developmental Dyslexia: Testing the Predictions of the Dual-route and Connectionist Frameworks." *Cognition* 126 (1): 20–38. doi:10.1016/j.cognition.2012.08.007.

Pickering, Susan J., and Paul Howard-Jones. 2007. "Educators' Views on the Role of Neuroscience in Education: Findings From a Study of UK and International Perspectives." *Mind, Brain, and Education* 1 (3): 109–113. doi:10.1111/j.1751-228X.2007.00011.x.

Prentice, Deborah A., and Dale T. Miller. 2007. "Psychological Essentialism of Human Categories." *Current Directions in Psychological Science* 16 (4): 202–206. doi:10.1111/j.1467-8721.2007.00504.x.

Rappolt-Schlichtmann, Gabrielle, Catherine C. Ayoub, and Jenna W. Gravel. 2009. "Examining the 'Whole Child' to Generate Usable Knowledge." *Mind, Brain, and Education* 3 (4): 209–217. doi:10.1111/j.1751-228X.2009.01071.x.

Reading Horizons. 2013. "Dyslexia – Learning Disability Information – Reading Horizons." Accessed September 4. http://www.readinghorizons.com/research/dyslexia/dyslexia-learning-disability-information

Ritchie, Stuart J., Eric H. Chudler, and D. Della Sala. 2012. "Don't Try This at School: The Attraction of 'Alternative' Educational Techniques." In *Neuroscience in Education: The Good, The Bad and The Ugly*, edited by S. Della Sala and M. Anderson, 244–264. Oxford: Oxford University Press.

Rogers, Carl. 1994. *Freedom to Learn*. 3rd ed. New York: Merrill.

Rose, L. Todd, Parisa Rouhani, and Kurt W. Fischer. 2013. "The Science of the Individual." *Mind, Brain, and Education* 7 (3): 152–158. doi:10.1111/mbe.12021.

Rubinsten, O., and A. Henik. 2009. "Developmental Dyscalculia: Heterogeneity Might not Mean Different Mechanisms." *Trends in Cognitive Sciences* 13 (2): 92–99. doi:10.1016/j.tics.2008.11.002.

Sadker, David, and Karen Zittleman. 2009. *Still Failing at Fairness: How Gender Bias Cheats Girls and Boys in School and What We Can Do About It*. New York: Scribner.

Sheridan, Kimberly, Elena Zinchenko, and Howard Gardner. 2005. "Neuroethics in Education." In *Neuroethics: Defining the Issues in Theory, Practice, and Policy*, edited by Judy Illes, 265–276. New York: Oxford University Press.

Shonkoff, Jack P. 2010. "Building a New Biodevelopmental Framework to Guide the Future of Early Childhood Policy." *Child Development* 81 (1): 357–367. doi:10.1111/j.1467-8624.2009.01399.x.

Shonkoff, Jack P., and Susan Nall Bales. 2011. "Science Does Not Speak for Itself: Translating Child Development Research for the Public and Its Policymakers: Translating Research for Policymakers." *Child Development* 82 (1): 17–32. doi:10.1111/j.1467-8624.2010.01538.x.

Stein, Zachary. 2010. "On the Difference Between Designing Children and Raising Them: Ethics and the Use of Educationally Oriented Biotechnology." *Mind, Brain, and Education* 4 (2): 53–67. doi:10.1111/j.1751-228X.2010.01085.x.

Stein, Zachary, Bruno Della Chiesa, Christina Hinton, and Kurt W. Fischer. 2011. "Ethical Issues in Educational Neuroscience: Raising Children in a Brave New World." In *Oxford Handbook of Neuroethics*, edited by Judy Illes and Barbara J. Sahakian, 803–822. Oxford: Oxford University Press.

Sylvan, Lesley J., and Joanna A. Christodoulou. 2010. "Understanding the Role of Neuroscience in Brain Based Products: A Guide for Educators and Consumers." *Mind, Brain, and Education* 4 (1): 1–7. doi:10.1111/j.1751-228X.2009.01077.x.

Szűcs, Dénes, and Usha Goswami. 2007. "Educational Neuroscience: Defining a New Discipline for the Study of Mental Representations." *Mind, Brain, and Education* 1 (3): 114–127. doi:10.1111/j.1751-228X.2007.00012.x.

Thibodeau, Paul H., and Lera Boroditsky. 2013. "Natural Language Metaphors Covertly Influence Reasoning." *PLoS ONE* 8 (1): e52961. doi:10.1371/journal.pone.0052961.

Trout, J. D. 2008. "Seduction Without Cause: Uncovering Explanatory Neurophilia." *Trends in Cognitive Sciences* 12 (8): 281–282. doi:10.1016/j.tics.2008.05.004.

US Department of Education. 2013. "IDEA – Building The Legacy of IDEA 2004." Accessed September 4. http://idea.ed.gov/explore/view/p/,root,dynamic,TopicalBrief,23

Uttal, William R. 2011. *Mind and Brain a Critical Appraisal of Cognitive Neuroscience*. Cambridge, MA: MIT Press.

Vidal, Fernando. 2009. "Brainhood, Anthropological Figure of Modernity." *History of the Human Sciences* 22 (1): 5–36. doi:10.1177/0952695108099133.

Vidal, Catherine. 2012. "The Sexed Brain: Between Science and Ideology." *Neuroethics* 5 (3): 295–303. doi:10.1007/s12152-011-9121-9.

Vohs, Kathleen D., and Jonathan W. Schooler. 2008. "The Value of Believing in Free Will Encouraging a Belief in Determinism Increases Cheating." *Psychological Science* 19 (1): 49–54. doi:10.1111/j.1467-9280.2008.02045.x.

Weisberg, Deena Skolnick, Frank C. Keil, Joshua Goodstein, Elizabeth Rawson, and Jeremy R. Gray. 2008. "The Seductive Allure of Neuroscience Explanations." *Journal of Cognitive Neuroscience* 20 (3): 470–477. doi:10.1162/jocn.2008.20040.

Willerman, Lee, Robert Schultz, J. Neal Rutledge, and Erin D. Bigler. 1992. "Hemisphere Size Asymmetry Predicts Relative Verbal and Nonverbal Intelligence Differently in the Sexes: An MRI Study of structure − Function Relations." *Intelligence* 16 (3–4): 315–328. doi:10.1016/0160-2896(92)90012-G.

Williams, Melissa J., and Jennifer L. Eberhardt. 2008. "Biological Conceptions of Race and the Motivation to Cross Racial Boundaries." *Journal of Personality and Social Psychology* 94 (6): 1033–1047. doi:10.1037/0022-3514.94.6.1033.

Witelson, S. F., I. I. Glezer, and D. L. Kigar. 1995. "Women Have Greater Density of Neurons in Posterior Temporal Cortex." *The Journal of Neuroscience: The Official Journal of the Society for Neuroscience* 15 (5 Pt 1): 3418–3428.

Wolff, Sula. 2004. "The History of Autism." *European Child & Adolescent Psychiatry* 13 (4): 201–208. doi:10.1007/s00787-004-0363-5.

Wood, Wendy, and Alice H. Eagly. 2002. "A Cross-cultural Analysis of the Behavior of Women and Men: Implications for the Origins of Sex Differences." *Psychological Bulletin* 128 (5): 699–727. doi:10.1037/0033-2909.128.5.699.