Redux-Neuroscience Meets Pedagogy

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The following piece was an invited commentary and featured as a guest entry on the blog of the Director of the Krasnow Institute, James L. Olds (krasnow.Blogspot.com) on Thursday, November 10, 2005. In the last year, there have been several editorial commentaries in top flight science journals on the topic of the potential for neuroscience to inform educational practice. Despite the historical reticence of the neuroscience community to comment on these possibilities, the engine of science, in search of meaningful questions, is headed in this direction……

This week’s editorial by Elsbeth Stern in the journal Science, “Pedagogy Meets Neuroscience,” is the crest of a wave that began back in June when The Journal of Neuroscience published the commentary, “Science Education: A Neuroscientist’s View of Translational Medicine” (Schwartz-Bloom, 2005) and Nature printed, “Big Plans for Little Brains” (Gura, 2005). The topics of each of these pieces address the potential for neuroscience to inform educational policy, intervention, and practice. This issue led to my interdisciplinary graduate training in educational psychology and neuroscience, which included experiments on the effects of Ritalin on learning and memory in hyperactive rats, and using EEG to explore the abilities of intellectually gifted and hyperactive adolescent boys to shift between academic and creative tasks. Michael Posner once shared with me videotaped discussions between cognitive scientists, neuroscientists, and education professionals brought together by a philanthropic organization in hopes of generating interdisciplinary research topics.

I have witnessed the approach-avoidance dance between the fields of neuroscience and education for about 9 years now. On one hand, neuroscience has been reticent until now to consider the paradigmatic influence that educational psychology could have on discerning relevant research hypotheses. Indeed, the neuroimaging methods we use to adequately explore cognition, its development, and the nature of individual differences are just beginning to mature from their infancy. In this same issue of Science, there is a report that anomalies in certain genes that guide brain development are now linked to dyslexia. But in many ways, the metric between neuroscience and education is still off. Cognition viewed in the lab doesn’t necessarily reflect “real-world” cognition, at least not in the way that practitioners think about it. On the other hand, educators have been quick to conform to whatever pieces of information about the brain they can learn from the popular press and self-proclaimed experts. Intervention techniques that currently exist perturb the plastic brain, but for how long?

John Bruer, President of the McDonnell Foundation, once proclaimed it a “bridge too far” to cross. Now, just recently, the National Science Foundation has laid the foundations of those bridges with their Science of Learning endowments to University of Washington, Stanford, Dartmouth, Carnegie-Mellon, and Boston University. In my own talks about the neuroimaging studies that my lab performs on nonverbal reasoning, I preface remarks to educational audiences with two main topics. First, why it looks like we know so much when we know so little. Indeed, until the advent of neuroimaging, members of the animal kingdom were our “age-old experts.” And second, the need for developing greater scientific literacy so that people are equipped with the skill to evaluate translated scientific information. The challenge on the front of science involves innovating experimentation that will allow us to characterize cognitive function with greater ecological validity so that neuroscience can potentially inform and reform how we educate. We also have a responsibility to promote scientific literacy. The challenge on the front of education is to refrain from conforming to ideas and information that are still new and unreplicated.

So, what does this mean for the field of gifted education in particular? In the review article “The Functional Anatomy of Talent,” I outline key intersections between cognitive neuroscience, gifted education, and psychological and psychometric measures of intelligence and expertise (Kalbfleisch, 2004). There are areas that are ripe for extended investigation using the tools and methods of cognitive neuroscience. We still know very little about the typical functional signatures of the developing brain when it is engaged in cognitive processes associated with learning and higher level thinking.

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In the shorter term, however, clues about the gifted brain are emerging from structural neuroimaging studies. A recently published study suggests that the structural brains of individuals with superior levels of intelligence undergo developmental changes that are very different than the growth patterns associated with typically developing children (Shaw et al., 2006).

Shaw and colleagues studied the largest sample to date in individuals that span from early childhood age to young adulthood (307 individuals, ages 3.8–29 years) that begins to characterize the dynamic relationship between structural brain development and aptitude (IQ) as assessed by the Wechsler Scales of Intelligence. Specifically, the authors report that children with superior levels of intelligence experience a markedly different pattern of brain development from children with average and high intelligence. Children with superior intelligence appear to have thinner cortices in prefrontal cortex than others their age, followed by a rapid increase in cortical thickness which peaks around age 11 and wanes later in adolescence. The prefrontal cortex facilitates processes associated with higher level cognition such as working memory and reasoning. The authors suggest this pattern creates the opportunity for optimal plasticity over the course of development and may help explain some of the individual differences we see in developing children. The average intelligence group displayed a pattern of continuing decline in orbitofrontal areas (located at the very bottom of the prefrontal cortex) over the same period or an increase in superior areas of frontal cortex that peak around the ages of 7-8. In keeping with this, overall age-related changes were reported in that a negative correlation between cortical thickness and IQ was observed in early childhood (3.8-8.4 years) changing to an observed positive correlation in late childhood (8.6-11.7 years) and into adolescence (11.8-16.9 years). Other changes noted occurred in left hemisphere in middle prefrontal and inferior temporal areas of the brain which are reported to facilitate language abilities and higher level cognitive skills related to intelligence. It is important to note that no gender differences are reported in this study even though there are other papers that report gender differences in the development of language structures of the brain. Also, the authors do not delineate groups by specific IQ score ranges so one assumes that “average,” “high intelligence,” and “superior” levels all follow normed assignments according to the instrument.

In regard to the study of special populations of gifted, a structural neuroimaging study of the brains of one family with a high incidence of dyslexia and concomitant visual spatial talent provides evidence of differences in the parietal operculum (the auditory association cortex), an area of the brain involved in language processing (Craggs, Sanchez et al., in press). Though this study is conducted within one family, it suggests a correlational relationship between the presence of dyslexia, superior nonverbal performance IQ, and atypical development in this area of the brain.

So, there are potential bridges after all. Or, are there yet? These studies provide insight into the individual differences we observe between children whether they are deemed gifted or not. But does it suggest change in how we teach them? As gifted educators, we already know that the brains of these children are extraordinarily plastic. We see it in how quickly they assimilate knowledge, in the breadth and depth of their memories, or in their performance within the specific domain or skill where they display expertise. The one potential change I can foresee is that this may be counter-evidence for a teacher who is unwilling to differentiate for a young gifted student, or a school district who will not allow children below a certain age to take advanced coursework because their brains are not ready to handle the complexity and abstraction. Beyond that, however, we still need to wait for science to unearth the functional templates associated with typical and atypical developmental function.

The last several months I have engaged in a series of conversations on two continents with scientists and educators who are trying to delineate meaningful and complimentary research areas between mathematics education and cognitive neuroscience. This exercise is not trivial. There are vocabulary differences, the metrics do not scale to one another, and the lab environment and the classroom (and the types of thinking that occur in each one) are two different places and impact thinking in different ways. While blueprints for the bridges are being sketched, it is also important to remember that the river over which this bridge will cross varies in size depending on the geography and location of the crossing-over point. If the bridges are barely discernable to the research community and the foundations are in process of being laid, then policy makers, classroom educators, and professionals in gifted education must continue to garner enthusiasm, but temper it wisely whilst the bridge is still under construction. After all, we want the bridge to meet the other side before we send people on the walk over.

References


