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Education and neuroscience

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EDITORIAL

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This Special Issue of *Educational Research* called for papers focusing on a new and exciting area of interdisciplinary research emerging at the interface between neuroscience and education. On the face of it, the need for such research appears obvious. If we are learning so much about the brain, surely this can help us improve education? Arguably, you might say teachers are the only professionals charged with the daily development of brain function, and one scientist (Koizumi 2004) has even suggested that education might be defined as a 'nurturing of the brain'.

Between 2005 and 2006, the ESRC-TLRP seminar series 'Collaborative Frameworks in Neuroscience and Education' brought together over 400 teachers, neuroscientists, psychologists and policy-makers to discuss the potential for collaborative work that might lead to improved educational and neuroscientific understanding. This Special Issue of the journal brings together and examines many of the issues and opportunities highlighted by the seminar series, by drilling down into just a few of many topics touched upon in the associated commentary (Howard-Jones 2007). Public interest in neuroscience and education has been considerable, as reflected by media coverage and the unprecedented accessing of the seminar series commentary (more than 110,000 downloads in the first 6 months). But this enthusiasm also brings with it dangers, as evidenced by the long-running success of entrepreneurs in constructing and promoting unscientific and unevaluated 'brain-based' pedagogy. It is appropriate, therefore, that the Special Issue should begin with a provocative article by John Geake scrutinising some of the most popular ideas about the brain to be found in today's classroom. Geake examines ideas about using 10% of our brain, left- and right-brain thinking, Visual Auditory Kinaesthetic (VAK) learning styles and multiple intelligences (as they are often interpreted in education). All these concepts are appealing in their simplicity and may resonate with some educational viewpoints. However, while they have usually been inspired by something related to neuroscience, any scientific basis has been so seriously misinterpreted, over-interpreted and/or misapplied that they are classified here as 'neuromyths'. By pulling the fallacies apart, Geake provides a convincing argument for developing a mutually comprehensible language and genuine interdisciplinary dialogue, in order to avoid these and future pitfalls.

By the end of Geake's article, the reader may be left asking: 'if these were just neuromyths, then what are we learning about education and the brain that is genuine and important?' In considerable contrast to the concepts critiqued by Geake, the next four papers in this Special Issue provide fascinating examples of how brain research is revealing insights about learning that have genuine implications for educational practice. Usha Goswami reviews what we know about the core neural systems involved with learning to read and the biological basis of developmental dyslexia. In so doing, Goswami highlights the complementary role of different brain imaging techniques in constructing this understanding, suggesting that future studies should draw selectively upon these techniques and approach difficult issues of causation through longitudinal design. As in other areas of educational interest, there are relatively few developmental studies of the

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brain and reading at present, with most neuroimaging studies involving only adult participants. This is partly due to the inappropriateness and difficulty of using some imaging methods with children, such that child-friendly techniques like EEG appear set to develop a special significance within neuroscience and education. Goswami also draws attention to the exciting possibility that EEG may be helpful in identifying early neural markers of risk for developmental dyslexia in infants.

Goswami demonstrates convincingly that existing studies suggest dyslexia is associated with an under-activation of key networks involved with reading, but also notes the shift during normal development of the brain areas involved with language as they become increasingly left-lateralised in most readers. This theme of shifting activity during development is picked up in the third paper by Sashank Varma and Daniel Schwartz. The essential role of cognition as a bridge between neuroscience and education is well known, but Varma and Schwartz ask the important question of how this bridge should be best conceptualised. Theoretical approaches are divided into an 'area focus' that understands a cognitive competency in terms of one brain area, and a network focus that explains it as a product of collaborative processing among many brain areas. It is clear from Varma and Schwartz's analysis that this difference in scientific theorising can have direct implications for the interpretation of results in terms of educational practice. An approach that highlights qualitative shifts in underlying networks also prompts educational ideas about how best to design and schedule support for such shifts, with potential implications for curriculum and teaching strategy.

Liane Kaufmann, in her paper, provides a further example that illustrates the importance of a network focus approach, and draws attention to developmental differences in the neural mechanisms linking numerical processing and the use of fingers. Before focusing on this particular aspect of early numeracy, she makes the point that single-deficit models, corresponding to Varma and Schwartz's 'area focus' approach, have probably been more popular in the literature because they are simpler and more testable than dynamic, process-oriented and multiple-deficit approaches. This is one example of why caution must be applied when considering how ideas from education, which often embrace the situated and complex nature of learning, can be combined with concepts arising from natural science perspectives that embrace parsimony. Kaufmann, as Varma and Schwartz, provides a coherent argument why such a more complex approach is required and emphases that, despite the additional difficulties this provides for scientific investigators, such complex models are more likely to lead to meaningful conceptual links between mind, brain and education. Kaufmann's own research in studying numerical development emphasises the value of neuroimaging techniques, especially when they reveal differences that are not reflected in performance. Once again, a shifting in underlying neural networks during development is revealed, and this leads to the suggestion that fingers may have a special role as concrete embodied tokens for representing number magnitude. Finally, Kaufman tentatively proposes the explicit incorporation of finger-use in intervention programs for dyscalculia as a potentially interesting area for future research.

While a body of research now exists linking numeracy and literacy with brain function, the area of music and the brain is only just starting out. For that reason, the contribution by Lauren Stewart and Aaron Williamon is particularly welcome, and provides a pioneering review of literature identifying a new and potentially very rewarding area for research. Consideration of the neural basis of music also focuses the reader on issues of cultural context and individual differences since, as Stewart and Williamon point out, music does not exist in the outside world, but is made sense of by multiple brain areas across both hemispheres. While all brains are supremely adapted for making links and

seeking patterns and meaning, the way this is achieved with music varies widely between cultures and also between individuals within the same culture. Stewart and Williamon's paper also dissuades us from any notion that biology is destiny. They review evidence for natural abilities with a genetic origin, but make the point that these do not develop by biological maturation alone, but require stimulation through practice and learning. Deliberate practice is the prime predictor of changes in performance and the neural processes associated with them. Even after a short period of training on musical notation, learners show behavioural and biological evidence of processes becoming automatic, with evidence from other (non-musical) studies showing how changes in function can, in the longer term and across the life-span, become associated with structural changes. This undermines the popular notion that differences at a brain level must indicate some type of biologically determined issue. Stewart and Williamon review many more insights, including issues of memorising music, and the apparently valuable role of neurofeedback in enhancing performance. In furthering research that combines neuroscience with music, or any other educational area, I would strongly support Stewart and Williamon's proposal that integrated neuroscientific, behavioural and observational studies are needed.

However, mindful of our first paper by Geake, what is to stop the many insights and ideas emerging from these areas of research in neuroscience and education becoming just another set of 'neuromyths'? Even VAK probably began with a scientifically observable piece of evidence – e.g., that we exhibit individual preferences in how we learn. Somewhere along the line(s) of communication, this commonsense notion mutated into the need for children to be labelled V, A or K and for teaching styles to be differentiated accordingly. Scientific findings are never likely to directly translate into lesson plans, so what sort of communication processes would help produce pedagogical concepts that are more educationally useful and scientifically credible than the present neuromythology? In the final contribution to this Special Issue, Howard-Jones, Winfield and Crimmins explore this important question, by reporting on an interdisciplinary attempt to co-construct pedagogical ideas spanning neuroscience and education. The context was drama education, but the findings echo some of the general issues highlighted by other authors in this issue. In particular, it highlights the ease with which neuromyths can be generated but also the immense, and mostly untapped, relevance of our understanding of mind and brain to education. Trainee drama teachers co-constructed their ideas with a research team possessing educational and appropriate scientific expertise. Interestingly, trainees passed through a series of observable stages in their approach. After initial enthusiasm and the generation of more neuromyths, a daunting sense of complexity arose before participants started focusing on models of cognition mutually informed by neuroimaging studies, and then began reflecting upon their practice with a new sense of depth and insight. Was the process we observed here in any sense reflective of the broader processes whereby neuroscience is beginning to influence educational thought? If so, I would speculate that we may now be at that daunting stage of realising that neuroscience has no ready-made prescriptive answers for education. Instead, through careful integration of scientific insights with educational expertise and understanding, what we are learning about the brain and the mind is promising to enrich educational perspectives in more subtle, meaningful and valuable ways.

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