From brain scan to lesson plan

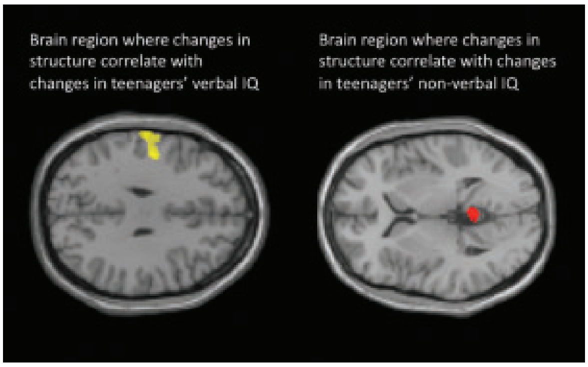
Michael Thomas, Director of the Centre for Educational Neuroscience, sheds light on the emerging discipline and why it is so relevant now…

In 2008, the Centre for Educational Neuroscience was formed, spanning three institutions within the University of London. It combined the world-leading expertise in neuroscience at University College London with that in child development at Birkbeck College and in education at the Institute of Education. Similar research initiatives are underway at Bristol and Cambridge in the UK and at Harvard and Stanford in the US.

Education and neuroscience are a natural fit. Education is about enhancing learning, while one of the aims of neuroscience is to understand the biological mechanisms responsible for learning. By bringing education, psychology and neuroscience together, the ultimate goal is to design better learning environments through the lifespan, which will lead to more effective and more fulfilled learners. Indeed, a recent report published by the Royal Society, entitled Neuroscience: Implications for Education and Lifelong Learning (February, 2011), envisioned a future where educational practice can be transformed by science, just as medical practice was transformed by science in the last two centuries. However, the dialogue must be two-way: an understanding of the brain mechanisms of learning will inform educational practice, but equally the education agenda will guide the direction of neuroscience research.

One might argue that teachers have long been ready for educational neuroscience: a report by the Economic and Social Research Council in 2007 entitled Neuroscience and Education: Issues and Opportunities, noted that 90% of surveyed teachers believed that knowledge of the brain is important in the design of educational programmes. 'Brain-based' educational programmes have been around for two decades. However, these programmes often had no involvement of neuroscience expertise and their effectiveness was rarely scientifically evaluated. The enthusiasm for neuroscience applications in education has led to commercial exploitation that is sometimes in advance of the neuroscience data (or indeed independent of it).

To date, neuroscience research has had a limited impact on educational delivery. One reason is that formal education presents a challenge for neuroscience, because it concerns a different kind of learning. Whereas most neuroscience investigates what the learner discovers through interaction with his or her environment, formal education concerns what it takes to acquire the knowledge



Verbal and non-verbal IQ can each change across the teenage years by up to 20 IQ points

developed by generations of experts. The extended, structured learning environments provided by education are powerful enough to sculpt new brain systems, such as those involved in reading and mathematics. Neuroscience also presents a challenge to the discipline of education, for example to make use of the research on the neural and genetic factors now known to influence the effectiveness of learning.

There are several areas where neuroscience is likely to have an initial impact on education. These include identifying what children should be taught when, and in what sequence. A clearer understanding of the neural basis for different aspects of conceptual and representational organisation will provide a much more secure platform for curriculum design. More widely, much of the emphasis on early intervention for disadvantaged children has been driven by neuroscience data on the malleability of the brain across age. Neuroscience can also help identify methods to enhance learning at different ages, and, in time, it will reveal the causes of variations in children's behaviour, such as giftedness on the one hand and disabilities like dyslexia, dyscalculia, attention deficit hyperactivity disorder, conduct disorder, and autism on the other.

As with any emerging field, there may be some initial scepticism. Educators know a lot about teaching. Will neuroscience merely explain why current teaching methods are effective, or will it offer new insights? Here are three examples of research that point to the latter.

Educators (and indeed psychologists) previously believed that children's intelligence stabilised by 10 years of age. In

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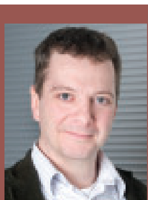
a new study teenagers were followed from 13 through to 17 years of age and their intelligence tested at the two time points. The study found that verbal and non-verbal IQ could each vary in children by up to 20 IQ points (IQ has an average of 100 and a normal range from 85 to 115). Importantly, brain scans carried out at the two time points found that in specific regions of the brain, structural changes in the amount of grey matter correlated with verbal and non-verbal IQ changes – both confirming that the IQ changes were real and giving some insight into the brain structures responsible for variations in intelligence. Intelligence can change well into the teenage years, indicating the time span over which a child's potential is still being realised.

In a second example, neuroscientists investigating conduct disorder and its relation to bullying have discovered two separate developmental pathways to these problem behaviours – and importantly, different interventions are appropriate to each. One group of children show callous, unemotional traits in addition to conduct disorder. These children find it hard to empathise with their victims and do not respond to punishment. A second group of children do not show these traits, but instead have problems with emotional regulation and threat perception. For this second group, a conventional intervention is appropriate for cases of bullying. It focuses on anger management, encourages the children to empathise with their victims, and punishes instances of bullying. However, this approach will not work with the first group. These children do not empathise, or respond to punishment. Instead, interventions must appeal to their reward-based brain systems: solutions must appeal to the child's self-interest, while simultaneously reducing the child's perceived rewards for their bullying, such as peer group respect.

In a third example, researchers investigating children's learning of science have begun to explore why children develop narrative accounts of how the physical world works that are often at odds with their perceptual expectations. When cartoon characters run off a cliff, they move out over the chasm, stop, and then drop vertically (followed by a small puff of dust as they hit the chasm floor). Children tell similar 'narratives' of how they expect moving objects to fall under gravity. Yet they are able to catch a ball based on the 'perceptual expectation' that it will follow a parabolic (curved) downward trajectory. The difficulty is that it is the narratives that dominate when it comes to efforts to consciously understand and explain events – as in science lessons – creating a major barrier to progress. Better integration of perceptual evidence with conflicting verbal concepts offers a way forward, but this rests on coordinating activity within the pre-frontal cortex, an area of the brain usually associated with attention, planning and decision-making. Primary age children vary considerably in these latter abilities. They therefore need to be helped by providing experience of suitable task contexts over time, in which they experiment with physical effects at the same time as engaging in verbal dialogues aimed at explaining their observations. These findings point towards the beginnings of a new framework for teaching science to young children.

As educational neuroscience develops, there remain bridges to be built. Neuroscientists and educators use very different vocabularies. Educators sometimes think research into biological or genetic causes of behaviour implies determinism (ie that children's fate is fixed by their genes), but this is far from the case. Biology provides no simple limit to learning because learning itself influences biology. Psychology will play a crucial role in mediating the links between neuroscience and education, and ensuring that insights into the operation of the individual brain are integrated into the community-based phenomenon that is the classroom. While there may be no direct link from brain scan to lesson plan, the pathway can be established via psychological theories of learning. Educational neuroscience is an emerging discipline that will be highly influential in designing the classroom of the future.



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