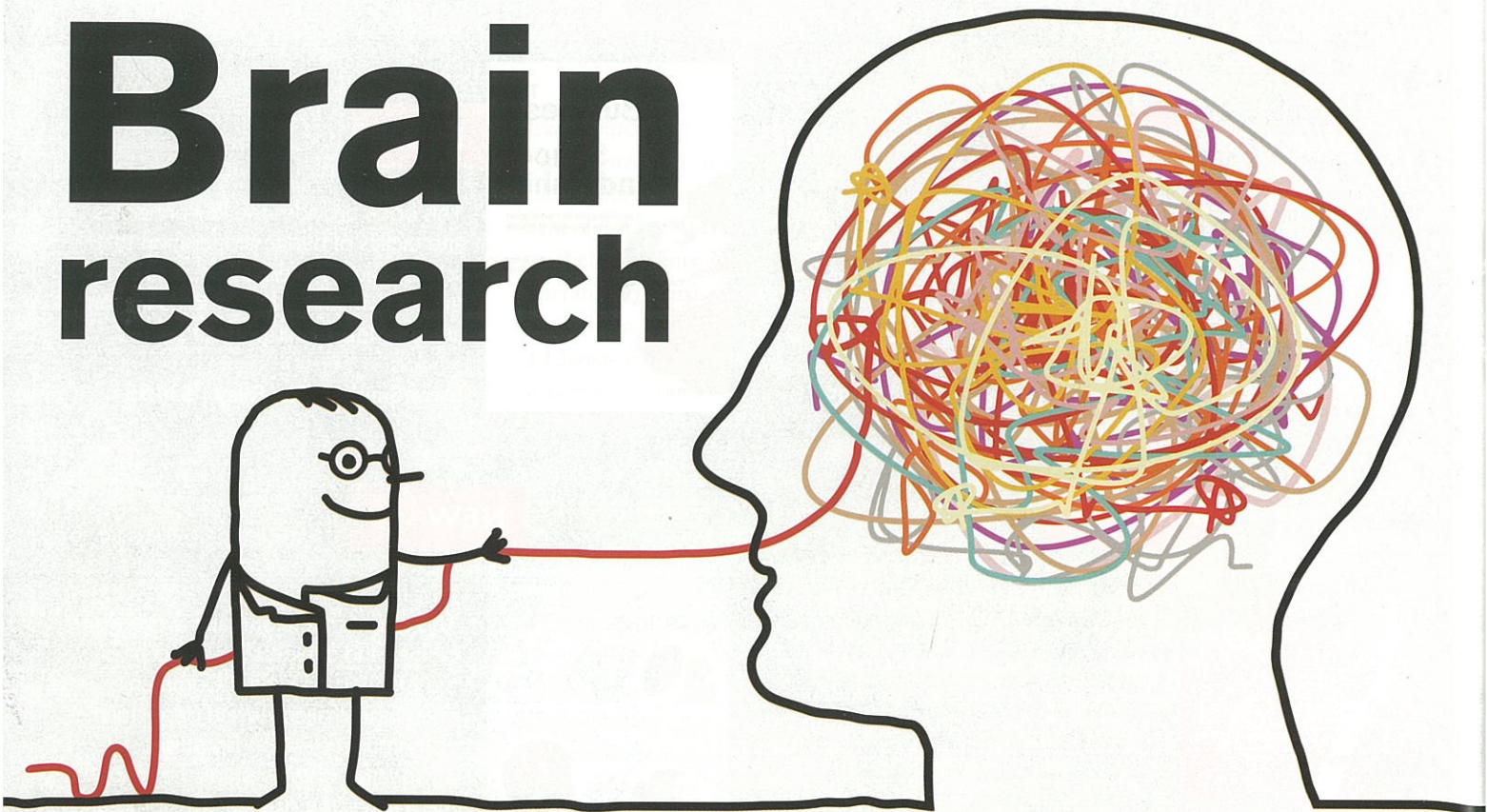


Brain research



and its implications for education

RESEARCH INTO HOW THE BRAIN WORKS AND HOW CHILDREN LEARN IS BEGINNING TO YIELD RESULTS EDUCATORS CANNOT IGNORE, SAYS ROBYN COLLINS.

Until the late 1960s and early 1970s, scientists and doctors believed that the brain was 'hardwired,' that is, the brain anatomy was fixed and that after childhood the brain changed only when it began the long process of decline. In the '60s and '70s, however, scientists showed that the brain changed its structure with every activity it performed, perfecting its circuits so it was better suited to the task it was performing, as Norman Doidge explains, in *The Brain that Changes Itself*.

That means that while certain parts of the brain do tend to be responsible for specific functions, areas overlap and can be 'co-opted' into performing one another's functions. If the one pathway gets blocked, the brain is very good at finding alternative pathways. Furthermore, the more a particular path is used, the more ingrained that use

becomes, and pathways near one another become associated with each other. If a path is under-utilised, over time it will be co-opted by other pathways that are branching out and need more space. If we fail to use certain pathways in the brain we will 'lose' them.

The term used to describe the brain's ability to change with new learning and constant practice is 'neuroplasticity.' Neuroplasticity occurs in the brain:

- at the beginning of life, when the immature brain organises itself
- in the case of brain injury, to compensate for lost functions or maximise remaining functions, and
- throughout adulthood, whenever something new is learned and memorised.

While the brain has apparently been underestimated, neuroplasticity isn't all good news; it renders the brain not only

more resourceful but also more vulnerable to outside influences in that it has the power to produce more flexible but also more rigid behaviour. Ironically, as Doidge explains, neuroplasticity produces some of the most stubborn habits and disorders because once a particular change occurs in the brain and becomes well established, it can prevent other changes from occurring.

In *The Brain that Changes Itself*, Doidge describes cases where the brains of people who were once thought to be incurable are being 'brought back to life.' These include:

- Roger Behm, a blind man who is able to see via his tongue
- Cheryl Schiltz, written-off by doctors when she lost her sense of balance due to a drug's side effects, who has now regained her balance and returned to normal life

- I Michelle Mack, who despite being born, literally, with half a brain is able to function in society and hold down employment, and
- I Michael Bernstein who suffered a debilitating stroke in the prime of his life that completely paralysed the left side of his body, is now back to his former life as his brain functions have been re-routed and re-invigorated.

In this last case, Bernstein's good right arm was immobilised and he was set to cleaning tables with his paralysed left arm. The task was at first impossible. Then slowly the bad arm remembered how to move. He learned to write again, to play tennis again and return to his earlier life as the functions of the brain areas damaged in the stroke transferred themselves to healthy regions. The brain compensated for the damage caused by the stroke by reorganising and forming new connections between intact neurons.

Basically, as Pascale Michelon explains in 'Brain plasticity: How learning changes your brain,' the research is showing that the brain never stops changing as we learn and thus, because of plasticity, we can change the brain through learning, form new connections, and change the brain's internal structure. As the research shows, over time, as people become expert in a specific domain, the areas in the brain dealing with the type of skill will grow. Researchers Eleanor Maguire, Katherine Woollett and Hugo Spiers have found that London taxi drivers, for example, have a larger hippocampus than London bus drivers because this region of the hippocampus is specialised in acquiring and using complex spatial information in order to navigate efficiently. Taxi drivers have to navigate around London whereas bus drivers follow a limited set of routes.

Similarly, as Andrea Mechelli and colleagues point out, plasticity can be observed in the brains of bilinguals. It appears, say Mechelli and co, that learning a language changes the left inferior parietal cortex. This suggests that expertise in language actually causes functional changes in the brain: the left inferior parietal cortex is

larger in bilingual brains than in monolingual brains. Bogdan Draganski and colleagues have also found that the learning of abstract information develops particular regions in the brain known to be involved in memory retrieval and learning.

What does this mean for schooling? At least four major findings of brain research have important lessons for educators.

The first relates to the importance of building 'pathways' in the brain to assist in the development of skills considered desirable in the 21st-century learner.

Through the 19th and early-20th centuries a classical education often included rote memorisation of long poems in foreign languages, which strengthened the auditory memory and hence thinking in language. It also included an almost fanatical attention to handwriting, which probably helped strengthen motor capacities and thus not only helped handwriting, but added speed and fluency to reading and speaking. Often a great deal of attention was also paid to exact elocution and to perfecting the pronunciation of words. As Doidge notes, such traditional exercises were dropped in the 1960s on the basis that they were too rigid, boring and 'not relevant.'

Doidge argues that the loss of these drills has been costly, as they may have been the only opportunity that many students had to systematically exercise the brain function that gives us fluency and grace with symbols. Their disappearance may also have contributed to the general decline of eloquence, which, he points out, requires memory and a level of auditory brainpower unfamiliar to most people now. For example, when Abraham Lincoln and Stephen Douglas in the United States conducted their slavery in 1858, they each comfortably spoke for an hour or more without notes, in extended memorised paragraphs. Most of us now give presentations with the ubiquitous PowerPoint – which, as Doidge describes it, is 'the ultimate compensation for a weak premotor cortex.'

Clearly, if there are certain skills and abilities we wish young people to have, brain

research can inform teaching and learning by identifying those activities which develop critical pathways in the brain. If, therefore, we consider fluency and grace with symbols to be important, we would consider there should be at least some rote memorisation in our school programs.

The second important, some might say obvious, finding of the research is that the more we practise a skill, the more expert we become. Closely tied to the idea of practice is the finding on how we master new skills. Doidge describes an experiment carried out by Alvaro Pascual-Leone that helps in the understanding of how students master new skills.

Working with blind subjects, Pascual-Leone mapped the motor cortex to see how they mastered the learning of Braille. The subjects studied Braille five days a week for two hours a day in class, followed by an hour of homework, over a period of 12 months. When Pascual-Leone mapped the brain, he found interesting differences between the readings on a Friday after subjects had been training for five days and on Mondays when they had rested from classes for two days. From the beginning of the study, Friday maps showed very dramatic and rapid expansion, but by Monday these maps had returned to their baseline size. The Friday maps continued to grow for six months and then stubbornly returned to baseline each Monday for six months. After six months the Friday maps continued to increase but at a slower rate, while Monday maps showed the opposite pattern.

Monday maps didn't show any change until after six months of training; then they increased, slowly plateauing at 10 months, when the speed at which subjects could read Braille on Fridays correlated more strongly with the speed on Mondays. After 10 months, the students took two months off. When they returned, their maps were unchanged from the last Monday mapping two months earlier; that is, while daily training led to dramatic short-term changes, over the weekends and months more permanent changes were seen on Mondays.

The significance of these findings for schools and students is obvious and helps us understand what teachers must do to help students truly master new skills and explains why ‘cramming’ for a test can bring short-term results but not permanent mastery. It’s relatively easy to improve when we cram for a test because we are strengthening existing synaptic connections, but we quickly forget what we’ve crammed, as did the Braille students when they rested from class on the weekends. Maintaining improvement and making a skill permanent both require the slow, steady work that forms new connections. If learners think they are making no cumulative progress, or feel their minds are ‘like a sieve,’ they need to keep at the skill until they get it – the ‘Monday effect.’ In Braille students, this took six months.

Another implication arising from this research is the effect of long holiday breaks from school. The experiment by Draganski and co involved 12 people in their early 20s who learned a three-ball juggling trick over three months until they could sustain a performance for at least one minute. Another control group of 12 did not juggle. After three months, the jugglers showed a significant increase in grey matter in a particular area of the brain related to visual movement. The researchers were somewhat surprised as they’d predicted a change in the area of the brain related to motor skills. The finding makes sense, however, when you consider that the skill the beginner most needs to acquire in order to juggle is to estimate where the ball will go – visual dexterity – before moving their hand in the right direction before the ball gets there – motor dexterity.

The importance of the experiment, though, was the next step; what happened when the newly acquired skill was allowed to stagnate? The participants were asked not to practise their skills and their brains were scanned again after three months. The amount of grey matter had reduced, supporting the idea that the brain operates in a use-it-or-lose-it fashion.

For schools, reducing the length of holidays or providing opportunities for students to practise skills during their long holidays would likely save many hours of learning time to re-teach what has been lost over the break from classes.

The third implication for educators relates to the learning environment itself. Animals raised in enriched environments – surrounded by other animals, objects to explore, toys to roll, ladders to climb, running wheels and the like – learn better than genetically identical animals that have been reared in impoverished environments. Acetylcholine, a brain chemical essential for learning, is higher in rats trained on difficult spatial problems than in rats trained on simpler problems. As Doidge notes, mental training or life in enriched environments increases brain weight by five per cent in the cerebral cortex of animals and up to nine per cent in areas that the training directly stimulates.

Trained or stimulated neurons develop 25 per cent more branches and increase their size, the number of connections per neuron and their blood supply. These changes can occur later in life but they do not develop as rapidly in older animals as in younger ones, perhaps because in an immature brain the number of connections among neurons, or synapses, is 50 per cent greater than in the adult brain. When we reach adolescence a massive ‘pruning back’ operation begins in the brain, and synaptic connections and neurons that haven’t been used extensively die off.

Two important findings for educators arise from this research: first, a highly enriched play environment is essential for the development of the young brain, and teachers can assist this development by providing stimulating environments in the early years of schooling; and second, close attention to developing the essential skills before young people reach adolescence is critical if we want to ensure that important brain connections are not lost.

For policy makers, attention to the environment provided for young people before

they reach school age is likely to have positive outcomes, both socially and economically, for future development.

Doidge suggests that if every child had a brain-based assessment and, where problems are found, a tailor-made program to strengthen essential areas in the early years when neuroplasticity is greatest, the implications for education would be immense. It is far better to nip brain problems in the bud than to allow children to wire into their brains the idea that they are stupid.

Finally, brain research has shown encouraging results for people with learning disorders. According to Carolyn Cosmos, writing in the *Washington Diplomat*, findings on brain neuroplasticity hold out hope for people with learning disorders such as dyslexia. Dyslexia affects vision and hearing as well as the ability to read, write and spell. Because people with dyslexia are of normal or superior intelligence, diagnosis and equally the lack of diagnosis can lead to a host of problems in schools. Behavioural issues related to underachievement, misdiagnoses, low self-esteem, social isolation and the inability to keep up with peers academically can all result from dyslexia and, while dyslexia appears in many different forms, it always affects reading, a skill essential for school success.

As Christopher Walsh, head of the Genetics Division at the Children’s Hospital in Boston, points out, in Cosmos’s ‘Brain training: Neuroplasticity research offers hope to people with dyslexia,’ ‘Reading is one of the hardest things our brains do. It demands we use many different parts of our brain at once.’

A study led by Walsh’s colleague Nadine Gaab of the Cognitive Neuroscience Laboratory at the Children’s Hospital in Boston looked at another piece of the dyslexia puzzle: problems in processing sounds and difficulties in linking sounds to letters on a page. The study used brain-imaging and brain-training software to examine and modify the difficulties children with dyslexia have with language sounds. In brain images of nine- to 12-year olds, Gaab observed how

children responded to fast-moving versus slow-moving sounds, in addition to comparing the brains of normal children to those with developmental dyslexia. She found that children with developmental dyslexia, whose reading problems stem from a faulty understanding of the sounds that make up their native language, may lack the proper brain wiring to process fast-changing sounds such as the rapid 'd' at the start of 'Daddy.'

The exciting thing about the study is that it suggests the brains of these children can be 'rewired.' Using Fast ForWord language software, developed by a company in California, Gaab completed brain scans on the children involved in the experiment before and after they undertook Fast

ForWord training. Results showed that these sound-training exercises not only improved reading, they could literally rewire the brain – and, says Cosmos, researchers have the scanned brain images to prove it. Gaab also suggests that other forms of sound training, such as musical training, might help children whose primary problem is sound processing and a faulty language map in the brain. Her goal is to catch and treat dyslexia before children begin learning to read.

The significance of such findings is immense. If students with dyslexia could be diagnosed and assisted early they could be saved years of frustration and low self-esteem.

Research into how the brain works and how children learn is beginning to

yield results educators cannot ignore. As Doidge observes, 'The idea that the brain can change its own structure and function through thought and activity is, I believe, the most important alteration in our view of the brain since we first sketched out its basic anatomy and the workings of its basic component, the neuron.' **1**

Robyn Collins is Manager of School Services for Independent Schools of Queensland. This is an edited version of her article first published in ISQ Briefings, the monthly newsletter of Independent Schools of Queensland, reproduced with kind permission.

For references, visit <http://teacher.acer.edu.au>