

# Teacher

EDUCATION MAGAZINE

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# Neuroscience and education

## Enhancing all students' capacity to learn

WHAT DO YOU DO IF A STUDENT HAS TROUBLE LEARNING DESPITE YOUR BEST EFFORTS? NEUROSCIENTISTS ARE BEGINNING TO UNDERSTAND WHY SOME STUDENTS TO LEARN EASILY AND OTHERS STRUGGLE, AND WHAT TO DO ABOUT IT, AS MARTHA BURNS EXPLAINS.

EDUCATORS WHO SEEK TO IMPROVE the effectiveness of educational methods have traditionally taken two primary routes: improved curriculum and enhanced professional development.

*Teaching Reading*, the report of the National Inquiry into the Teaching of Literacy, chaired by Dr Ken Rowe, Research Director of the Learning Processes and Contexts research program at the Australian Council for Educational Research, made recommendations in 2005 on both these domains: curriculum and professional development. The *Teaching Reading* report highlighted the importance of training teachers in evidenced-based methods of teaching reading, emphasising systematic, explicit phonics instruction for foundational reading proficiency and providing an integrated approach to reading that supports the development of oral language, vocabulary, grammar, reading fluency and comprehension.

In recent years, professional development in many countries has stressed helping teachers standardise curriculum content and adhere to standards which are assessed by periodic uniform testing.

An element of the optimum educational outcome that has been harder to tackle using this model is the natural ability and motivation to learn that the student brings to the classroom. What does a teacher do, for example, if a student has trouble learning phonics or if fluency lags behind accepted norms despite the best efforts of the teacher and use of the accepted curriculum? Educators are constantly plagued by the question, 'Is it the teacher's fault when a child cannot learn?' Every classroom has a proportion of students who continue to struggle to learn to read despite the best attempts to provide various interventions. Most teachers and administrators agree that some of the problem seems to involve the learner – the question is, how?

In the past 10 years, neuroscientists have begun the effort to solve this problem. Neuroscience is a scientific discipline that includes a range of areas that explore, among other things, how the human brain learns and what factors affect that learning. As neuroscientists begin exploring what human cognitive variables enable some students to learn easily and others to struggle, the answers are, predictably, complex but factors have emerged that are leading to an understanding of 'why Johnny still can't read.'

### **Learning capacity equals brain plasticity**

All humans who do not have a damaged brain or a marked developmental delay have the capacity to learn throughout the lifespan. It's remarkable, for example, that each of us, at any stage in our lives, can if we choose learn a foreign language and become reasonably competent with that language after about 100 hours of instruction. This capacity to learn new things has a neurological basis: as we learn, the brain changes.

Brain changes occur each time a person learns and retains new information. The term brain scientists use for this capacity is neuroplasticity. Neuroplasticity is evident when a child learns to rhyme, say, or an adult masters the tricky click wheel of an iPod. The brain changes involve new connections that form among brain cells – neurons – as well as chemical changes that enable those connections.

Learning capacity or neuroplasticity is known to vary as we age. In a young child, learning takes place without any effort. Consider the best example: the way young children acquire language. During the first few years of life, a child learns his or her native language without any effort. As long as a child is exposed to a language of any kind, the child's brain will begin to organise itself to perceive relevant acoustic differences which characterise the meaningful speech sounds of that language.

Each language has its own set of distinct characteristics that are used to distinguish one meaningful sound from another, so a child's brain must learn to 'hear' those features that are distinguishing in the native language and ignore features that are not. If mother smacks her lips or throws a kiss, those are sounds, but not speech sounds. Somehow the child must sort this all out. The remarkable thing is that almost every child with normal intelligence and normal hearing does this without any effort on the child's part or any 'teaching' going on by the parents.

Researchers have shown repeatedly that the child does not need to be 'listening' to speech or paying attention to speech; the brain organises on its own. But, as any adult who has tried to learn a second language knows, after this critical period in infancy ends, learning to 'hear' the differences between speech sounds of second languages requires careful attention to the speech sounds; we must be taught what to listen for and what to ignore. All humans have this neurological capacity to change, which we call learning. And although it's easier when we're young, the brain can grow, adapt and learn at any age. The brain changes that result are actually new connections between and among neurons.

### **Learning speed equals brain efficiency**

How easily the brain processes new information, changes and adapts, that is, learns, may be referred to as brain efficiency. Often, brain capacity and efficiency overlap, but not always. Educators use the term 'quick learner,' euphemistically, to refer to a student who learns easily. We all differ with respect to cognitive areas where we learn easily and others where we do not. Walter Isaacson, in his recent biography of Albert Einstein, *Einstein: His Life and Universe*, noted that as a student Einstein was not especially 'quick' at maths. In fact, during the early years

of forming his special theory of relativity, and even in later years, Einstein relied on colleagues, including his first wife, to help him develop mathematical formulae to represent his theories. So one could say that Einstein was very efficient at learning and applying many scientific concepts, but not as efficient as one might expect with mathematical concepts.

Neuroscientists consider brain efficiency as speed of processing. Like capacity, it can vary from one cognitive domain to another and even from one sense to another. Hearing specialists or audiologists, such as my colleague Dr Nina Kraus at Northwestern University, and cognitive psychologists, like Dr Paula Tallal at Rutgers University, both in the United States, have attributed some of the problems of young children in learning language to early limitations with hearing efficiency. Not to be confused with deafness or hearing loss, the problem, called an auditory processing disorder, has been shown to represent, at least in part, a difficulty perceiving the rapidly changing acoustic patterns of speech.

Brain efficiency is also affected by brain chemistry. Most likely everyone has had the experience of 'processing slowly' when tired, or under the influence of alcohol or some medications. In these cases the brain's efficiency is slowed down by neurotransmitters that have an inhibitory effect on most processing. There are also neurotransmitters that make it easier to pay attention to new material and to hold on to newly learned information. These latter neurotransmitters are just starting to be understood.

Some of the neurotransmitters that researchers believe help with new learning include acetylcholine, which generally keeps attention levels high, dopamine, which maintains motivation and helps the brain save new connections, and norepinephrine, which among other things has been shown to keep one alert and interested in new material. It turns out

that the way we present information to a child or adult in many ways enhances these 'learning' neurotransmitters. For example, when a teacher uses novel materials, or commends a student on a job well done, norepinephrine and dopamine are naturally increased.

### Application to education

So what does this new brain science contribute to education? Neuroscience now helps educators in two ways. First, it can provide teachers with an understanding of why some kinds of learning may be more difficult for some students than others. And, perhaps more important, neuroscience is providing educational tools that enhance learning capacity and efficiency. Neuroscientists have demonstrated that all students exhibit different patterns of learning that equate to underlying cognitive capacities of memory, attention, processing and sequencing. Surprisingly, this has little to do with native intelligence or IQ; rather, it relates to learning patterns to do with attention, memory, processing and sequencing.

**Attention** Some students are better able to attend to the internal detail of words than are others. Those students who attend to internal detail of words are naturally 'good' at tasks like phonemic awareness: activities like rhyme and isolating initial consonants of words. Other students, however, despite equal intelligence, process words in the same way that most of us perceive faces, as a unit. Those students appear to pay more attention to the context in which a word is embedded, or the prosody of a sentence, than specific internal details. For example, when a person says, 'Wow, did I ever h--- a bad day!' the exasperation of the person speaking and context provided by the other words, and perhaps the speaker's facial expression and body language, help us to understand what the fifth word was, even though it wasn't spoken intelligibly. In fact, if we were in the room with the person, we might not need to hear much of what was said to get the gist of what the person meant.

Individuals who have auditory processing problems, or difficulty perceiving the internal details of words, get a great deal of practice relying on context and inferring meaning from other contextual cues. Those individuals might have excellent 'people skills' as a result, but they may also struggle to learn phonic decoding of words when they learn to read.

**Memory** For other students, attending to internal detail of words may be adequate, but they may have trouble remembering what they hear. Psychologists call this auditory working memory. If it affects remembering sounds of words, reading experts may refer to this as phonemic or phonological memory. Students who have trouble with this may have experienced difficulties learning grammatical endings and small grammatical words when they were learning their own native language. Later, when learning to read, they may struggle to remember which sounds go with which letters of the alphabet, or later still, remembering all the parts of directions given aloud or details from paragraphs they read or hear.

**Processing** We've already discussed processing speed as a cognitive efficiency variable that affects learning. As stated earlier, all of us learn some kinds of information more quickly and easily than others. Some of us are naturally quick at picking up athletic skills, others musical skills, still others scientific and mathematical skills. Students with auditory processing disorders may struggle to 'hear' information clearly in a classroom and may respond slowly to auditory instruction but do very well with other kinds of instruction that is more hands-on or visually based. These students may appear to have poor listening skills or seem to be poorly motivated for classroom activities. When those students are tutored in quiet rooms, one-on-one, however, they may show much better learning aptitude.

**Sequencing** Finally, some students struggle in learning how to deal with the order of sounds in words, words in sentences,

sentences in paragraphs and paragraphs in longer narratives. During early development, children with sequencing problems may have trouble learning rules of grammar and morphology, or the structure of word forms, getting confused about the use of prefixes, say, or grammatical word endings.

When they're learning to read, students with this difficulty may decode words reasonably well but struggle to comprehend what they read because the grammar and morphology confuse them. Small differences in the sequence of words or phonemes can entirely change the meaning of sentences that are almost alike. For example, the sentences, *the boy hits the ball* and *the ball hits the boy* require awareness of sequencing differences to know who or what is hit. Similarly, the sentences *the boy hits the balls* and *the boys hit the ball* vary in meaning due only to the change to the plural 's' ending.

### What can be done?

The exciting news from neuroscience is that computer-based programs are starting to be developed that can increase anyone's brain capacity and efficiency, at any age. A neuroscience company called Posit Science, in the US, has developed a product called 'Brain Fitness' that enhances attention, memory and processing speed in aging adults. Another neuroscience company called Scientific Learning, also in the US, has developed eleven educational products, called the Fast ForWord family of products, which are specifically designed to enhance students' capacity to learn language and to learn to read.

In addition, neuroscientists are reaching out to educators to help them enhance their teaching methods in ways that increase their ability to reach all students, regardless of learning styles or individual cognitive strengths and weaknesses. They're also helping teachers understand the ways in which they can enhance natural learning brain chemicals through new teaching methods and materials. In the last few decades, edu-

cators have developed excellent curricula and educational standards, opening doors to help them reach all students. Applying neuroscience to education promises to open many additional doors. ▀

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*She was the keynote speaker at the 'Rewiring The Brain For Academic Gain' conferences on the implications of new neurological and literacy research and educators working with children with learning difficulties in Melbourne, Sydney and Auckland in August.*

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