Big brain?

How the human brain evolved can teach us a lot about the way it learns and the most effective methods of teaching, says ***Professor Paul Howard-Jones*** in this extract from his book

The evolutionary history of our brain helps us realise how incredible our brains are. It helps us appreciate the importance of understanding how the brain functions when trying to understand and promote the ability to learn in schools, in the workplace or just for leisure. Let's look at three broad categories of process that are particularly relevant for education: processes supporting engagement for learning, building of knowledge and consolidation.

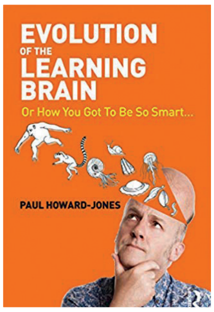
ENGAGEMENT FOR LEARNING

All learning begins with the learner attending to some source(s) of information or insight. A teacher, who represents one such source themselves, must be able to capture and maintain the learner's attention and judiciously direct it to whatever other sources of information and insight are helpful. There are ancient motivational and emotional biases that impact on our abilities to engage our attentional abilities, and these biases originally evolved to aid learning rather than disrupt it. Early on in our evolution as vertebrates, we evolved tendencies that bias our attention towards experiences that promise to be rewarding. Teachers offer a range of rewards that support engagement in the classroom, many of which are social ones (praise, gold stars, points, etc.) that contribute to self-esteem and social standing. These types of social reward influence the brain's reward system in a similar way to other incentives such as receiving money, food or even playing video games. When it comes to influencing our engagement, what is meant by the term 'reward' can, therefore, be very broad.

Novelty also attracts our attention, again stimulating our reward system in a way that can increase engagement and promote learning. Novel contexts can help engage students initially with a new topic, or help encourage them to apply and practise their freshly learnt knowledge in new scenarios. Topics that engage curiosity have also been shown to stimulate the brain in regions similar to those stimulated by reward. However, novelty and classroom rewards are not always necessary for engaging students because just sharing attention can, in itself, be rewarding. We have seen that our strong motivation to share attention is a uniquely human characteristic that may have played a key role in our ancient cultural accumulation of knowledge, as it does today. When self-initiated, this capturing of shared attention also leads to reward-related brain activations. This suggests that just prompting someone else to share attention with you can be a desirable thing to do. It may also explain why asking students to communicate their ideas to each other in different ways can help engage their interest in learning, whether they do this through addressing the class or through helping one another in pairs to master skills.

In contrast to features of an educational experience that encourage an 'approach' response, anxiety can produce avoidance of a topic and so prevent engagement. For example, avoidance is a well-established characteristic of maths anxiety. Maths-anxious students generate additional activity in regions of their amygdala associated with negative emotions and fearfulness. Fear conditioning evolved to keep us safe from physical danger, but it can operate both consciously and unconsciously in ways that are problematic for classroom learning.

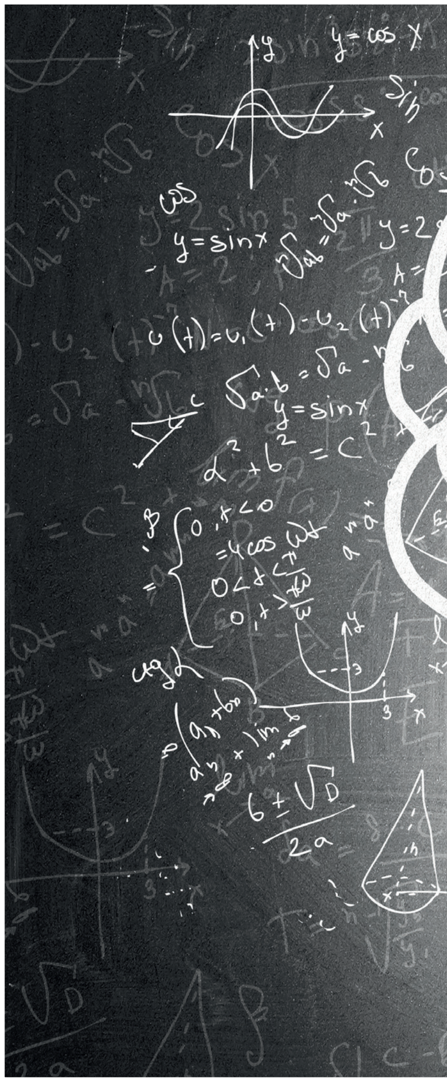
EVOLUTION OF THE LEARNING BRAIN: Or How You Got To Be So Smart (Routledge, £14.99)



Professor Paul Howard-Jones takes us on a journey through 3.5 billion years of evolution to explain current thinking on how our brains have evolved, how we learn and the implications for education.

Combining biology, neuroscience and educational insight, Howard-Jones tracks our evolution as social creatures, the emergence of language, literacy and numeracy and the development of education. Ending in the modern-day classroom, he gives a fresh perspective on the nature of human learning and an insight into the future of the learning brain.

To order a copy of the book, visit: https://bit.ly/2pG8cbR



Learning can come from many sources

Learning then, and particularly our inclination to engage with it, shares ancient roots with emotion and involves biases that educators should not ignore. As importantly, we have evolved systems of communication that support the unconscious communication of these emotions. This means teachers and parents may not even know when they are transmitting emotions likely to undermine or promote the learning of others. The mirror neuron system can support the social learning of actions and skills, but it can also help transmit positive and negative attitudes and emotional responses. Observing an emotion in someone else (e.g. through their expression) activates some of the same brain regions involved with experiencing those emotions. These unconscious workings of our brains help explain how easily negative emotions, such as anxiety about mathematics, can

PHOTOS ADOBE STOCK

but there is no substitute for the support of a good teacher, especially for children

be transmitted from teacher to student, and how positive teacher attitudes can become linked to higher student achievement. This emphasises the importance of a teacher being able to present concepts and knowledge with confidence and enthusiasm.

THE BUILDING OF KNOWLEDGE

Attending to sources of information in the outside world can open the door to learning, but the incoming information needs processing before a new concept is meaningfully represented in the brain. When we construct new and meaningful knowledge, different pieces of information from the world must be connected together with each other and with our prior knowledge. Constructing new thoughts and connecting these to old ones places great demand on our limited working memory – our ability to consciously attend to information.

This process of building new knowledge is perhaps the most modern part of everyday learning, benefiting from our capacity for conscious effortful thought and a range of modern, cultural supports. These supports are important because our working memory system is not greatly different to other species and its capacity in some respects is comparable to some other primates. In our prehistory, beads and scratchings on bone helped us compensate for the limitations of our mental abilities. Now, we have cultural artefacts such as books and the internet to support us. These help us to extend our limited capacities, to point us towards what we should be attending to and enabling us to build up our knowledge independently. Of course, it still takes effort to consciously link together the pieces of information we need. Sometimes you might notice yourself, or another learner, after attending closely to some source of information, averting their gaze away from what's in front of them. This is thought to help us avoid distraction while making the effort to connect everything up.

Although books and the internet are a great support for learning, perhaps the greatest source of support we can ever have at our disposal is a good teacher. Unlike material scaffolding, teachers can consider the internal world of the learner and mould the information they present according to whatever they find there. They can identify the concepts that can build on the learner's present understanding and select the most appropriate way to express these. They can also use their understanding of what the learner already knows by explicitly encouraging them to make appropriate connections with their prior knowledge. This is particularly important for children, because the neural circuitry required for making these connections is still developing. By presenting, clearly and concisely, just what's needed to meaningfully understand the concept, the teacher can reduce any unnecessary burden on the learner's working memory as they struggle to consciously put together new ideas in their mind. Differences in rates of learning and development mean that teachers need to continuously monitor what their students know and how they are thinking, and they need a good theory of mind to enable them to do this.

The ability to teach can seem almost like a superpower. Teachers rewire and restructure the brains of others in ways that can be as biological and, ultimately, as life-changing as the effects of neurosurgery. Usually, however, teaching is carried out with much more precision in terms of the consequences for mental ability. While a surgeon seeks out a brain region with a general function, a teacher targets those neural networks in their students that encode a specific set of memories, then helps them change the connectivity of these networks in very particular ways. Through skilful interaction with our minds, a good teacher literally transforms us, mentally and biologically.

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CONSOLIDATION OF LEARNING

All educational learning involves the learner engaging with information and using it to build new knowledge, but this is not the end of the story. Until consolidation, fresh knowledge is difficult to apply and vulnerable to loss. Somehow the knowledge must become more permanently embedded in our memory, and connected sufficiently to other ideas and different contexts so we can usefully apply it.

We have been evolving over billions of years to process information, rather than just to store and retrieve it. From the outset, the function of neurons was to transform incoming information and turn it into outgoing information. In other words, we have evolved to do something with information – not just to absorb it. Hardly surprising then that shallow processing – such as that involved with, for example, simply hearing a new word – leads to a poor memory for the word. To ensure consolidation of new information, it must be processed more deeply.

Carrying out a task that requires you to process the fuller meaning of new knowledge in different contexts is a double bonus. It can not only help you understand the knowledge better but will also help you remember it longer.

Testing is often used only to evaluate student knowledge, but it's an effective way of ensuring this deeper processing occurs and for accelerating the rate at which learning becomes consolidated. Being tested on material makes it more likely to be remembered in the final test, and more so than simply rereading the material. There is also evidence that testing slows the rate of forgetting in the longer term.

It works well for learning a diverse range of topics, over a wide range of education levels and for many different age groups. All of this points towards the need to provide engaging opportunities for students to be challenged on their understanding, but in low-risk tasks that are free of anxiety (unlike formal assessments). Recent neuroimaging research suggests that repeatedly retrieving information causes it to become represented in the brain in different ways – essentially connecting it with different meanings and making it easier to retrieve in the future.

Interestingly, however, one primal type of information processing has received less attention from educators. The conversion of sensory information into action has been a central organising principle of the brain that predates vertebrates – but

movement is rarely a priority in academic types of learning. Education may be missing a trick here.

When learning words and phrases, we know that performing appropriate gestures at the same

EVOLUTION AND A SCIENCE OF LEARNING

The other important way that evolution can help education is by providing a stimulus and framework for scientifically researching, understanding and thinking about the brain in education. To meet the challenge of bridging brain science and education, a new field of research emerged at the beginning of this century. It is still young, however. So young, in fact, that researchers have still to settle on a name for it. It gets referred to as 'Neuroeducation', 'Educational Neuroscience' or sometimes 'Brain, Mind and Education', with the 'Mind' emphasising how psychology is key to all these ventures.

This new area of research is using methods from classroom observation to brain imaging to develop a 'Science of Learning' for education. Research centres combining neuroscience, psychology and education are springing up around the world, together with postgraduate and professional training for teachers.

Researchers in these centres are focusing on how we learn, and how some strategies help us learn more effectively than others. The emphasis on 'how' reflects a belief that learning cannot be improved by just prescribing 'what works'. A student's learning is impacted by where they are learning, what they are learning and already know, their cultural background and many other factors.

Few prescriptions are likely to exist now or in the future that can be guaranteed to improve learning outcomes whatever the learner and their situation. Indeed, teachers rarely try to apply a 'one size fits all' approach to their students. Instead, they constantly adapt their teaching to the learner and the context, apply their own theory about their students' mental processes and so decide how best to scaffold these processes.

Possessing a scientific understanding of how these processes operate is important for teachers when developing their approach. It has been said that trying to teach without a scientific understanding of learning is a bit like trying to fix a washing machine without knowing how it works, and students, most would agree, are much more complex than washing machines.

Currently, however, there are very few examples of initial teacher education that include an understanding of how the brain learns. This lack of educational focus on learning processes gives a sense of the distance that education must travel in the years ahead. It also

time can enhance learning, at least compared to just reading and/or listening. This 'enactment' effect has been shown to work across a range of populations, including children, the elderly, those with cognitive and mental impairments, and Alzheimer patients. However, unlike testing, the use of movement is not entirely aligned with the 'sit still' ethos in many classrooms and it's easy to understand why many teachers might not be keen on the idea. But the evidence for learning through movement is accumulating.

Recently, a brain imaging study has provided a little more insight into how enactment works. This has confirmed that performing a gesture when memorising a word leaves a movement 'trace' in the word's representation in the brain. Enactment appears to activate an additional set of brain networks partially intertwined with those involved with learning the new concept, including networks for greater attention.

Sleep is another important part of consolidation that has been evolving at least since vertebrates began and possibly since the first central nervous system. This 'price for plasticity' must be paid but many of us end up in debt, and lack of sleep is clearly linked to academic underachievement among children…

In general, our evolutionary history encourages a shift in how we view learning and education to a perspective that includes our biological basis. This perspective gives strong emphasis to some concepts, such as emotion, attention and action, that are less emphasised in educational thinking – at least in respect of their significance for learning.

This is an edited extract from 'Evolution meets education', Chapter 9 of Evolution of the Learning Brain by Paul Howard-Jones (Routledge, £14.99)

NW SHOW MASTERCLASS

Paul Howard-Jones – professor of neuroscience and education at the University of Bristol and a regular contributor to Channel 4's *Secret Life of 4 Year Olds* – will be keynote speaker at the NW Show masterclass 'The brain, learning and the early years', where he will be looking at how learning occurs in the brain and what this means for early years pedagogy.

Joining him at the masterclass to talk about the importance of self-regulation and PSED in early learning will be Dr Sara Baker and Dr Jenny Gibson, principal investigators at the Centre for Research on Play in Education, Development and Learning (PEDAL) – established by The LEGO Foundation and located at the University of Cambridge.

THE MASTERCLASS

9.30-12.30 on Friday, 1 February

This forms part of an extensive programme of seminars at the two-day Nursery World Show in Islington, London.

➜ **To book and for more information, visit: www.nurseryworld show.com**

helps explain the global prevalence right now of myths about the brain that are associated with poor classroom practice.

The relating of neuroscience to learning in colleges, classrooms and the workplace is not entirely straightforward. For one thing, there are big differences in concepts and language between neuroscience and education. This gap between neuroscience and education provides an obvious challenge when 'making meaning' of our neurobiology in an educational sense, i.e. identifying key messages about what the neuroscience means for everyday learning and, as importantly, what it doesn't mean. However, evolution can aid this process of sense-making by guiding attempts to understand our learning brain through comparing it to that of other species.

This guidance includes clues as to the primal and foundational nature of some brain processes compared with others. For example, the timeframe of evolution gives more emphasis to vertebrate emotional biases than any alleged Stone Age modular bias.

In this way, evolution can also help identify the types of bias that might be targeted by future research. Evolution helps us understand how our brain was shaped and what it was shaped to do, and may provide an alternative perspective on difficulties with cultural inventions such as numeracy and literacy.

Finally, the inclusion of an authentic understanding of evolution in educational thinking can provide a first defence against evolutionary 'neuromyth'. In all these ways, evolution may prove vital for attempts to inform educational thinking, policy and practice with insights into how the brain learns.